JAN 18 1937

Engineering News-Record

McGraw-Hill Publishing Company, Inc. January 14, 1937 Twenty-five Cents, Five Dollars per Year

Wallkill Valley under which New York City soon will begin to drive a water tunnel reaching to the far hills, beyond the Hudson River, a distance of 23 miles

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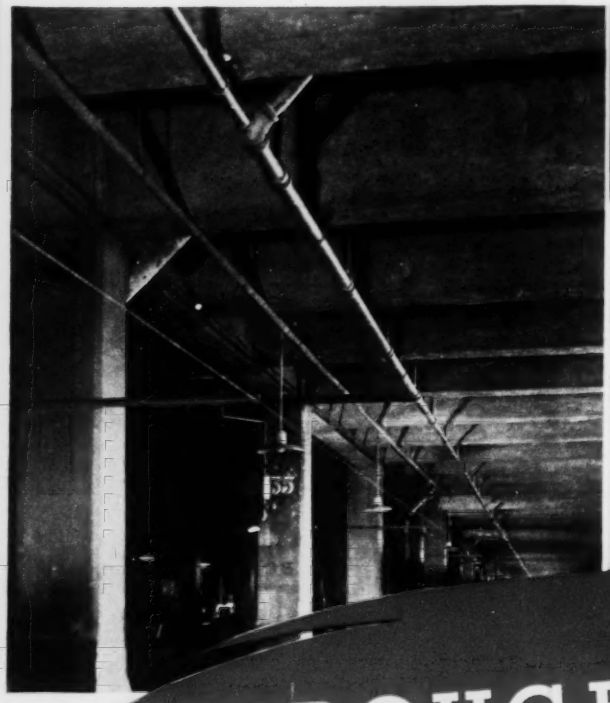

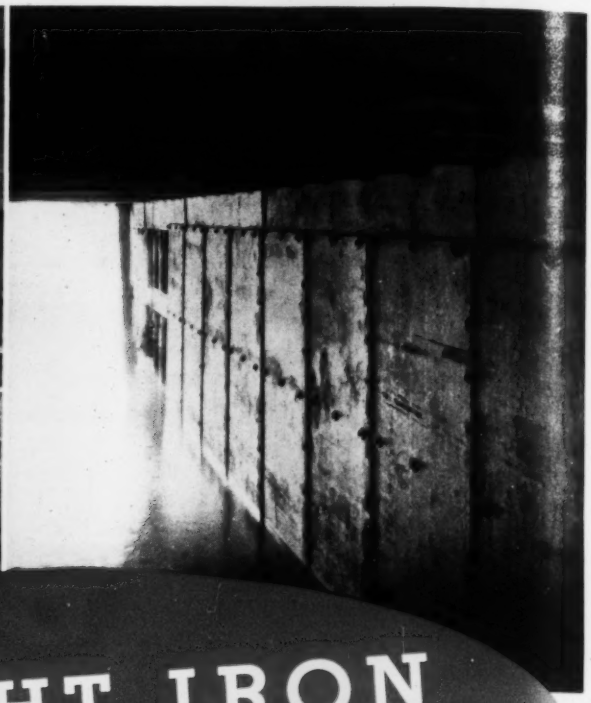

WROUGHT IRON
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Fire and Corrosion

● While sprinkler systems and fire curtains must wait for the threat of fire, they do not have to wait for the ever-present threat of corrosion. Choose the material for fire fighting that will not fail prematurely before duty call's — choose wrought iron.

Illustrated are two examples where corrosion is always present and where wrought iron was chosen because of its known long life under these conditions. Both of these are installations on the Pennsylvania Railroad. One is the sprinkler system of Byers Wrought Iron in the Polk Street Warehouse, Chicago, subjected to dampness and locomotive smoke. The other is the fire curtain of Byers Wrought Iron on Pier No. 6 in Baltimore subjected to salt water corrosion.

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To MAINTAIN Revived Earnings

NOW that the upswing of business recovery is so widely and unmistakably evident, there is a tendency in many quarters to let down. It is but natural that after so long and so severe a period of stress and anxiety, those who have borne the burden should welcome a chance to take it easy.

With the storm behind him and an apparently smooth sea ahead, many a business skipper now is beginning to think how good it will feel to get below, kick off his shoes, light his pipe and relax for a spell.

Fair enough! But before he yields to that craving it would be well for him to take a good long look ahead and to make sure that his course is well set to meet conditions as they may develop. For beyond the pleasant waters we now are sailing, lurk not a few reefs that may yet spell trouble for the reckless and the unwary. To be sure, they offer no hazard comparable with the storm we have just survived. Prudent navigators can avoid them. But that very fact is the most compelling reason why we dare not indulge at this time our temptation to celebrate.

IT is to be remembered that much of the golden shower that has so colored the closing months of 1936 results from a combination of rapidly growing volume and low costs. That is a happy situation but it cannot last. It never does. Already labor is talking about higher wages and shorter hours and in many quarters it is doing more than talk about them. Basic commodity prices are headed sharply upward. Taxes to pay the recovery bill are yet to be collected. All along the line producers are thinking and talking of higher prices for their wares.

From the producers' angle such a picture looks all to the good. But, after all, one producer's price becomes another's cost. So if business would continue to enjoy the earnings it now so cheerfully welcomes it must prepare against the day of higher costs all the way up and down the line.

Two courses are indicated: costs must be held as low as possible by constant effort to realize the highest production efficiency. That means modern equipment, close management and an avoidance of the overhead frills that creep so subtly into any business during the flush times of easy money.

And along with control of mounting costs is the equally important task of building sales. For it is volume that enables the production man to neutralize the inevitable increase in certain of his prime costs. During the year or two ahead of us that volume can be maintained only by harder selling and by more hard-hitting and consistent advertising than now is contemplated by all too may firms.

It is one thing to net a fine margin on a recovery volume at depression costs. But it will be quite another thing once those costs begin to catch up. Then the unit margin begins to dwindle and the aggregate margin soon melts away unless the volume is made to grow in proportion.

RIGHT now the far-sighted executive is planning to control his costs and build his sales during the coming year. He is putting his plant on the most efficient possible basis and he is strengthening his sales and advertising effort for the months ahead. He knows that such effort alone will enable him to maintain the revived earnings that he now welcomes with such enthusiasm.

Willard Chevalier

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THIS MODERN GRAVEL PLANT . . .

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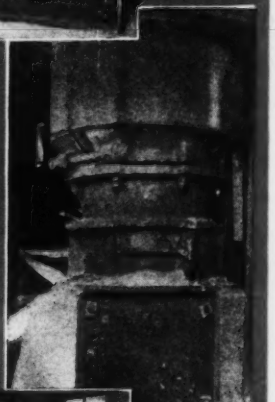

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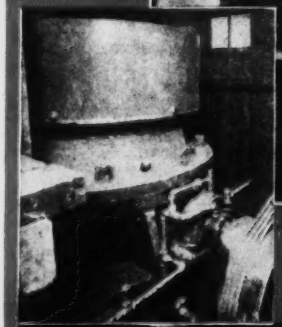

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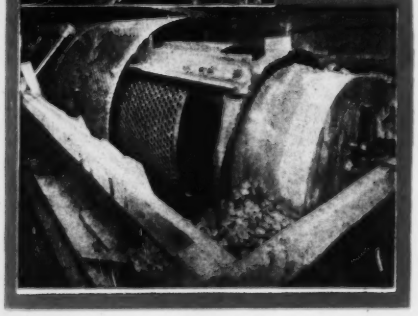

MEETS TODAY'S CONDITIONS

● In 1936, while most aggregate markets were over-produced, the Pioneer Fuel & Brick Co. of Butte, Montana, built a new gravel plant at Finlen, Mont. This completely modern plant was designed by Telsmith engineers to meet today's conditions. Each piece of Telsmith-built machinery is properly co-ordinated and balanced. The plant runs smoothly, efficiently *and profitably.*

Excavated material is delivered into the plant receiving hopper, equipped with a 16″x 5′ Telsmith Plate Feeder, and evenly discharged to an 18″x 66′ conveyor which takes it up to a 3 x 6′ Telsmith Double Deck Pulsator, used as a scalping screen. The screen's upper deck rejects the larger boulders to a Telsmith 8-B Primary Breaker; second deck rejects intermediate size to a Telsmith No. 32-B Reduction Crusher. All crushed material is returned to scalping screen for re-sizing before going to washing plant. Undersize passing the screen's lower deck goes to an 18″x 123′ Telsmith Belt Conveyor which discharges to a wash box. Water is added and raw material flumed to a 40″x 14′ Telsmith Ajax Rotary Washing Screen with blank and perforated washing sections, sand jacket, and gravel screening sections. Sand and water pass through the sand jacket and into a No. 5 Telsmith Sand Tank which separates coarse sand; overflow to a Telsmith No. 6 Sand Tank where fine sand is deposited. Each size of sand is discharged to a separate bin. Gravel is scrubbed, rinsed, sized and chuted to two separate bins. All storage bins are equipped with Telsmith Bin Gates.

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The Road Builders **are meeting in New Orleans this week. Next week's issue will carry the first reports of that meeting and of the Road Show. A report of the meeting of the Asphalt Technologists, held concurrently, will be published in the following issue.**

IT WON'T HAPPEN HERE!

One million people seriously injured in *one year* through traffic accidents. That's what the 1936 record will show.

"It's got to stop!" people shout indignantly . . . and go right on cracking bones and fenders.

So—the only thing highway officials *can* do is to make streets and highways as safe as possible. They find that Atlas White Markers, shown in the picture at the left, help tremendously. For these easy-to-see markers act as safety guides. They keep drivers in their own lanes, out of the other fellow's territory.

Atlas White Markers are strips of hard, durable concrete built right into the street or road. They *stay* in and they *stay* white. Rain can't wash them away. Heaviest traffic can't wear them away.

No maintenance or repair expense

Do not confuse Atlas White Markers with the painted-on kind. Atlas White Markers are a permanent part of the pavement itself. Their life is for the life of the pavement. Once installed, you never have to give them another thought. There's no maintenance. No repair expense. No replacement expense.

That's why highway and safety officials find that Atlas White Markers, although higher in first cost, save money over temporary methods in the long run.

Help build Safety into Streets and Highways with Atlas White Traffic Markers — Made with Atlas White Portland Cement—Plain and Waterproofed.

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Safety Markers of Atlas White Portland Cement on Super-Highway through Forest Park, St. Louis, Mo. Constructed by Webb-Boone Paving Company, St. Louis, under plans and specifications prepared by Missouri State Highway Commission.

ATLAS WHITE PORTLAND CEMENT FOR TRAFFIC MARKERS

ENGINEERING NEWS-RECORD
January 14, 1937

The Delaware Aqueduct Gets Underway

Construction operations on the long delayed water supply extention for New York City will be initiated with the sinking of 13 shafts on northern and southern sections of the 85-mile tunnel

ON TUESDAY of this week the Board of Water Supply of the City of New York opened bids on two contracts for the sinking of the first 13 of 30 shafts along the route of the Delaware aqueduct. The award of these contracts will initiate actual construction of the long-deferred $273,000,000 water supply extension project which includes an 85-mi. pressure tunnel and three reservoirs in the Catskill Mountains at the headwaters of the Delaware River and a tributary of the Hudson River. Contracts for the remaining shafts will soon follow and when the entire 30 are under construction, the combined length of which will total 18,000 ft., this undertaking will constitute one of the largest shaft-sinking operations ever underway at one time.

The Delaware project for an additional water supply for New York City contemplates developing 540 m.g.d. of water from Rondout Creek, a tributary of the Hudson River, and from the Neversink River and the East Branch, tributaries of the Delaware River. These watersheds, shown in Fig. 1, lie on the westerly and southwestly slopes of the Catskill mountains, between 80 and 115 airline miles from the city. Like the Schoharie and Esopus watersheds of the present Catskill system, which they adjoin, these new watersheds lie in a hilly region of high rainfall, sparsely populated and heavily wooded. The area is substantially free from limestone, and the water produced is exceptionally soft and of splendid quality.

This project, described in *Engineering News-Record* of Mar. 31, 1934, p. 698, will increase by more than 50 per cent the combined safe yield of the several New York city water supply systems, now estimated at about 1,039 m.g.d. In addition to the new supply, the Delaware aqueduct will also pick up about 100 m.g.d. from some of the higher reservoirs of the present Croton system, and deliver this water to the city at an elevation about 160 ft. higher than the present point of delivery.

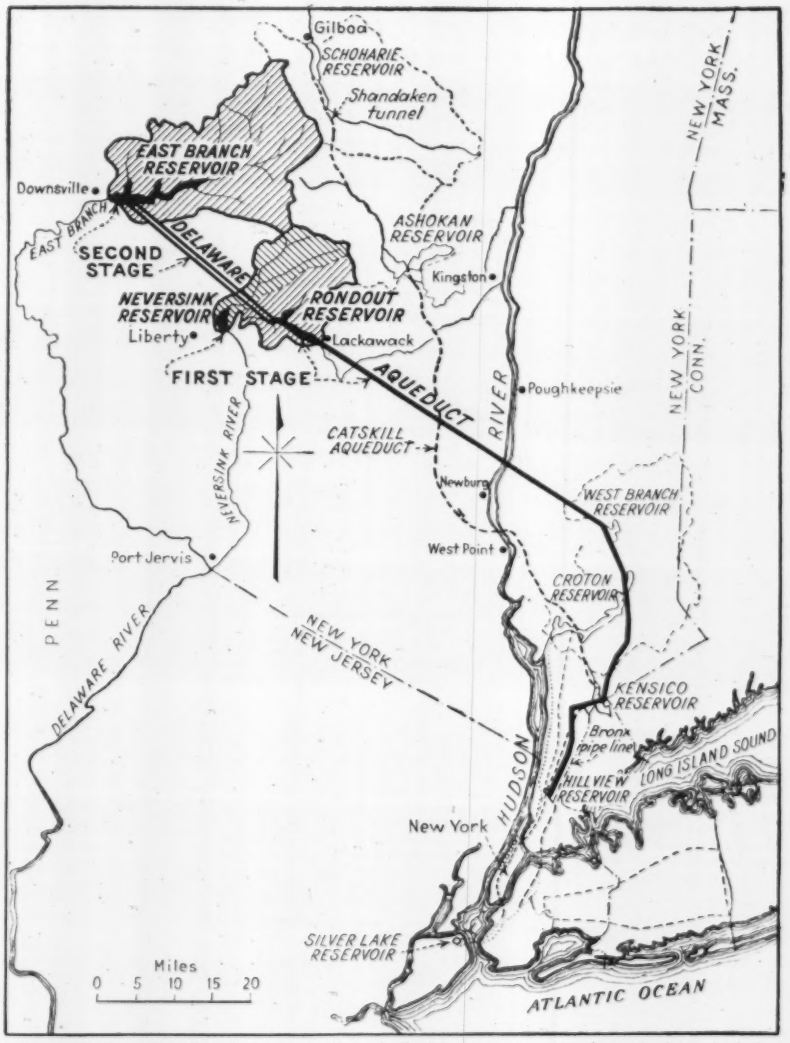


FIG. 1—THE DELAWARE project will be built in two stages, the first of which includes an 85-mi. aqueduct and two reservoirs—the Neversink and Rondout—interconnected with a short tunnel. The second stage, to be started later, comprises the East Branch reservoir and a tunnel connecting with the Rondout reservoir.

The Delaware project is to be built in two stages, the first embracing the 85-mi. pressure-tunnel aqueduct from the Rondout reservoir to the Hill View distributing reservoir at the northerly boundary of the city, the Rondout and Neversink reservoirs, and a short tunnel connecting these two reservoirs. It is expected that increasing consumption demands will necessitate beginning the second stage, comprising the East Branch reservoir and the tunnel to Rondout reservoir, before the first stage is completed.

That part of the Delaware aqueduct, the shafts of which are about to be put under construction, will transport

the water from Rondout reservoir, where the waters of the Rondout, Neversink and East Branch will be brought together, to the Hill View distributing reservoir in Yonkers. From this point just outside the city limits the water will be distributed to the five boroughs of the city through the two existing tunnels either by direct connection or via Hill View reservoir. The distribution tunnels are of the pressure type and have a combined length of 38 miles.

The water of the new Delaware system enroute to the city will be passed through the West Branch reservoir of the Croton system and through the Kensico reservoir of the Catskill system, the latter providing a large emergency reserve a few miles north of the city. While in ordinary operation the water will pass through these two reservoirs for additional sedimentation and for further purification by longer storage, provision is made for bypassing these reservoirs whenever conditions make this desirable.

Tunnel depth

As shown on the profile, Fig. 3, the Delaware aqueduct tunnel will lie from 300 to 1,000 ft. below the general level of the ground, with a maximum depth of about 2,500 ft. under the crest of the Shawangunk range. While details of the profile have been determined by consideration of drainage, the depth is mainly determined by the internal water pressure and the necessity of getting a sufficient cover of sound rock over the tunnel at all points to resist internal pressure without the use of a steel lining or reinforcement of the concrete lining of the tunnel. The profile also shows that the first stage of the Delaware aqueduct consists not of a single tunnel but of six successive tunnels, connected at their adjacent ends through gate houses where the flow between the uptake shaft at the discharge end of one tunnel and the downtake shaft at the inlet end of the next tunnel is controlled. For administrative convenience these several tunnels have been designated as shown in Table 1. The Kensico-Hill View tunnel consists of two parts, joined by a pair of shafts and a gate house through which the water can be delivered to and returned from the filters to be built at Shafts 19.

TABLE I — THE SIX TUNNEL SECTIONS OF THE DELAWARE AQUEDUCT

Tunnel	Shaft Numbers	Approximate Length Miles
Rondout-West Branch	1 to 9	45
West Branch bypass.....	9 to 10	2
West Branch-Kensico	10 to 17	22
Kensico bypass	17 to 18	2
Kensico - Hill View (Two sections)	18 to 1A	14
	Total.....	85

The contracts on which work will soon be started are essentially for the sinking and lining of the shafts to tunnel grade. They also include the excavation, but not the lining, of about 200 ft. of tunnel in either direction from the bottoms of the shafts, the excavation of underground powder magazines from these tunnel headings at certain shafts where surface magazines large enough for the construction of the main tunnels would be hazardous, excavations for gate houses and valve chambers at the tops of certain shafts, and incidental surface work. Excavation in limited lengths where enlargements are to be made under future contracts at the shafts will be lined throughout with concrete as they are sunk, generally dispensing with any form of steel or timber support. Two of the drainage shafts will be elliptical, but all other shafts are circular. The tunnels, all equipment in the shafts, and the gate houses and valve chambers with their equipment and superstructures, will be built under later contracts to be announced as work progresses.

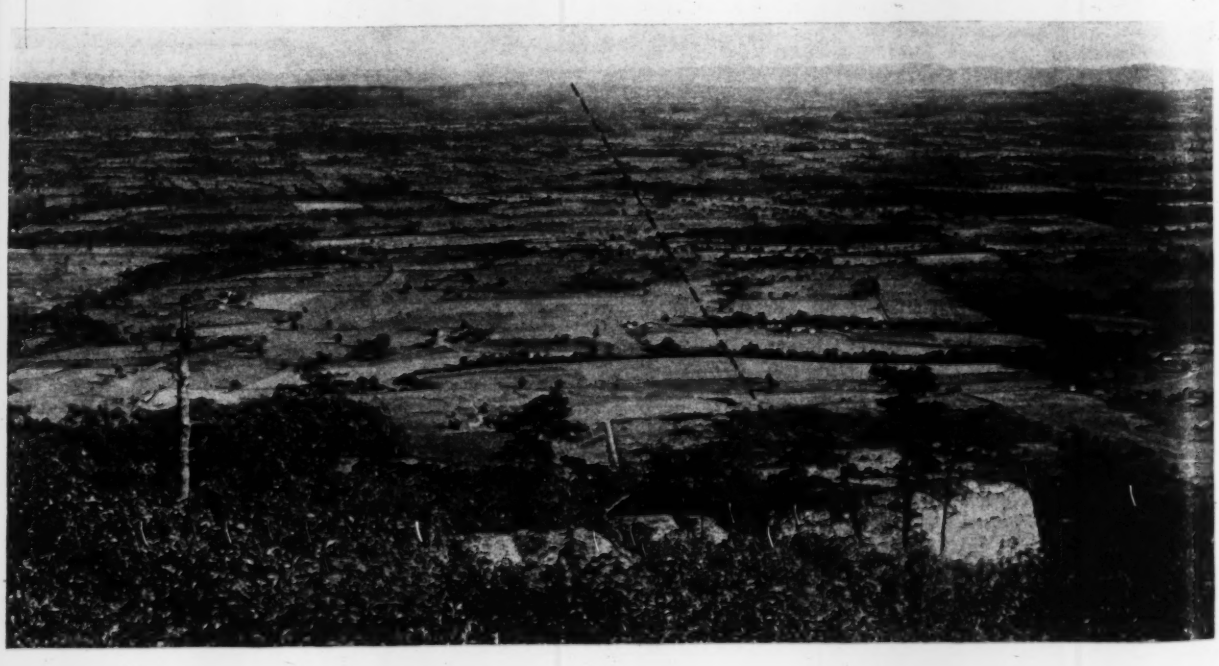
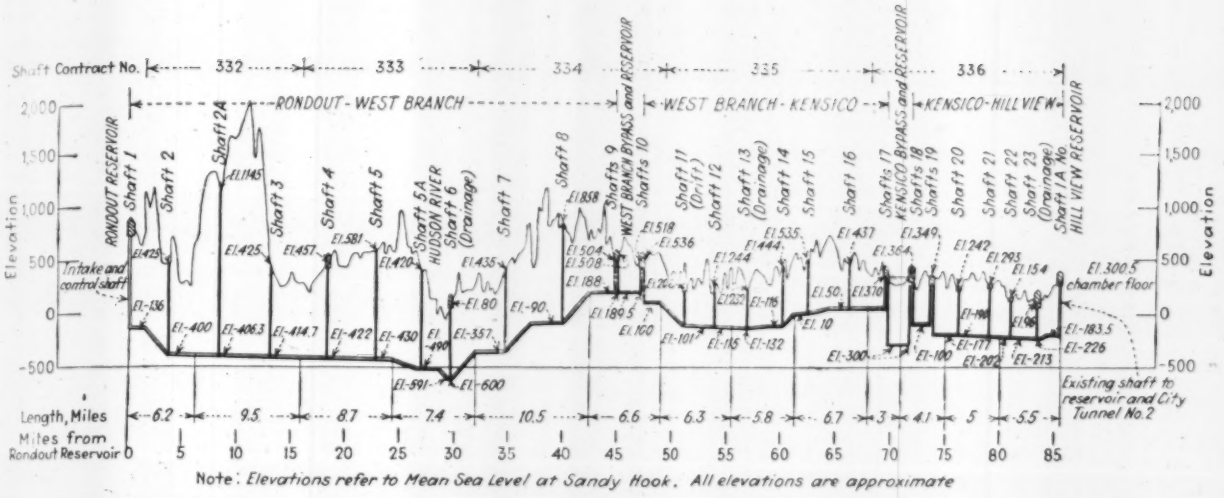


FIG. 2—TUNNEL LINE of the Rondout-West Branch section of the aqueduct. View looking southeast toward the Hudson River from the Shaft No. 3 on the Shawangunk range.

Reasons for past delays

As early as 1922 it became manifest that the Delaware River was the next logical source of water supply for New York City. The Delaware being an interstate stream forming parts of the boundaries between New York and Pennsylvania on the one hand, and between Pennsylvania and New Jersey on the other, negotiations were undertaken between commissions representing the three states for the arrangement of an equitable apportionment of the waters of this river. While the commissions were twice in unanimous agreement as to forms of compact, these compacts each time failed of ratification by the legislatures of some of the states, and in 1927 the Board of Water Supply recommended that the city delay no longer but proceed at once with the design and construction of the Delaware project.

This recommendation was approved by the Board of Estimate and Apportionment of the city on January 12, 1928 and by the State Water Power and Control Commission on May 25, 1929, but litigation by the state of New Jersey before the Supreme Court of the



Note: Elevations refer to Mean Sea Level at Sandy Hook. All elevations are approximate

FIG. 3—PROFILE AND shaft locations of the Delaware aqueduct for which bids have been received on contract sections Nos. 332 and 336. The six successive tunnels comprising the aqueduct are interconnected through shaft gate house controls

TABLE 2—DETAILS OF THE DELAWARE AQUEDUCT SHAFT CONTRACTS

Contract Number	Shaft Number	Purpose of Shaft	Approximate Depths—Ft. (a)	Finished Diameter	Approx. Earth Cover (b)	Predominant Rock Type	Connected Structure
	1	Construction, intake and control	950	14′ 0″	5	Ashokan sandstones and shales	Rondout Reservoir and intake gate house
332	2	Construction	825	14′ 0″	2	Ashokan sandstones and shales	
	2A	Construction	1,550	14′ 0″	5	Shawangunk grit and Hudson River shales, slates and sandstones	
	3	Construction	840	14′ 0″	26	Hudson River shales, slates and sandstones	
	Total	Contract No. 332, 3 shafts	3,215				
333	4	Construction and risers	880	14′ 0″	12	Hudson River shales, slates and sandstones	Connection to Catskill Aqueduct
	5	Construction	1,010	14′ 0″	15	Ditto	
	5A	Construction and riser	910	14′ 0″	3	Ditto	Valve chamber for local supply
	6	Construction, drainage and riser	680	26′ 6″	23	Ditto	Drainage chamber, also valve chamber for local supply
	Total	Contract No. 333, 4 shafts	3,480				
334	7	Construction	790	14′ 0″	0	Highlands gneiss	
	8	Construction	950	14′ 0″	0	Highlands gneisses and granites	
	9–Uptake	Construction and waterway	320	14′ 0″	14	Ditto	West Branch Reservoir, influent and effluent gate houses and bypass tunnel
	9–Downtake	Construction and waterway	320	15′ 0″	6	Ditto	
	10–Uptake	Construction and waterway	330	15′ 0″	8	Highlands gneisses and schists	
	10–Downtake	Construction and waterway	440	15′ 0″	0	Ditto	
	Total	Contract No. 334, 6 shafts	3,150				
335	11	Construction and riser	310	16′ 0″	40′	Highlands gneisses and schists with granite injection	Croton Falls Reservoir
	12	Construction	360	14′ 0″	56	Inwood limestone	
	13	Construction, drainage and riser	360	23′ 5″ x 29′ 8″ (ellipse)	14	Fordham gneiss	Cross River Reservoir
	14	Construction	560	14′ 0″	0	Fordham gneiss	
	15	Construction	525	14′ 0″	15′	Fordham gneiss with interbedded limestone	
	16	Construction	390	14′ 0″	3′	Fordham gneiss with granite intrusions	
	Total	Contract No. 335, 6 shafts	2,505				
336	17–Uptake	Construction and waterway	320	15′ 0″	0	Fordham gneiss with granite intrusions	Kensico Reservoir, influent and effluent gate houses and bypass tunnel
	17–Downtake	Construction and waterway	670	18′ 0″	0	Ditto	
	18–Uptake	Construction and waterway	660	18′ 0″	40′ (Caisson)	Manhattan schist	
	18–Downtake	Construction and waterway	460	19′ 6″	60′ (Caisson)	Manhattan schist	
	19–Uptake	Construction and waterway	450	19′ 6″	30′	Manhattan schist	East View filter site and gate house
	19–Downtake	Construction and waterway	530	19′ 6″	30′	Manhattan schist	
	20	Construction and risers	430	16′ 0″	8′	Manhattan schist	
	21	Construction and risers	495	16′ 0″	10′	Manhattan schist	Risers and underground shaft-head valve chambers, for local supply
	22	Construction and risers	370	16′ 0″	24′	Fordham gneiss with granite intrusions	
	23	Construction, drainage and riser	320	22′ 0″ x 32′ 2″ (ellipse)	14′	Fordham and Yonkers gneiss	
	Total	Contract No. 336, 10 shafts	4,705				
	Grand total	5 contracts and shaft 1 = 30 shafts	18,005				
	1A–North	Construction and waterway	Sunk under previous contract				Hill View Reservoir, City Tunnels 1 and 2

(a) Depths refer to finished invert of tunnel and are approximate.
(b) Near centers of shafts; does not include decayed rock.

United States prevented progress until that Court decided in favor of the city on May 4, 1931.* The depressed financial conditions then existing further delayed the beginning of construction and it was not until June 5, 1936 that funds for the first year's construction work became available. The tunnel west of the Hudson River, where the shafts are deepest, had been originally laid out, in the interests of economy, with longer headings and fewer, and on the whole, shallower shafts; the shafts on either side of the Shawangunk range for instance, being eight miles apart, and the others five to six miles apart. This portion of the tunnel was to be placed under construction earlier than the remainder so that all parts could be finished at the same time. The delays above cited, however, making it imperative to complete the project with all possible speed, necessitated the relocation of all shafts west of the Hudson River and the addition of two more shafts, including the 1,550 ft. shaft, No. 2A, in order to shorten the controlling headings and thereby expedite the completion of the first stage of the project.

The contracts for which bids have been received, Nos. 332 and 336, are respectively at the northerly and southerly ends of the tunnel. The former section, on account of its great depth, is being advanced because of the long time required for construction; the latter (Kensico-Hill View tunnel) because it is urgently needed both to safeguard the city against an interruption of that part of the Catskill aqueduct between the emergency reserve storage in Kensico reservoir and the city, and to provide sufficient capacity to adequately handle peak demands which will soon exceed the capacity of the Catskill aqueduct. At the present time about 60 per cent of the entire normal supply of the city and a larger part of the peak demand is drawn through this part of the Catskill aqueduct, and it could not be shut down for even a day without serious consequences. It has long been considered essential, in the interests of safety, to have a second line of supply from Kensico reservoir to the city.

Of the other shaft contracts, Nos. 333 and 334 (Fig. 2) are scheduled for advertising within a few weeks, but No. 335, involving neither great depths nor extreme urgency of completion, will be somewhat longer deferred.

Shaft contract details

Contract 332 is for three shafts of a maximum depth of about 1,550 ft. and a combined depth of about 3,220 ft., all simple construction shafts of 14 ft. finished diameter inside of the concrete lining. Except for details at the tunnel junction and for closures at top and bottom, these shafts will be substantially completed under this contract. Contract 336 is for ten shafts ranging in depth from 320 to 670 ft., with a combined depth of about 4,700 ft. Six of these shafts are arranged in three pairs, the shafts of each pair spaced from 50 to 135 apart. These shafts will be permanent waterway shafts and they are from 15 to 19.5 ft. in diameter. Shafts 20, 21 and 22 will ultimately be closed in their upper parts with concrete plugs through which will pass two steel riser pipes of 48 in. diameter inside the concrete lining. These risers will deliver water to valve chambers at the shaft heads for the supply of Westchester County communities, the city being under legislative mandate to furnish water to any community desiring it in the nine counties outside the city traversed by its works. The remaining shaft, No. 23, will ultimately be equipped as a drainage shaft for unwatering the Kensico-Hill View tunnel for inspection or repair. This shaft, too, will be provided with two 48-in. risers for the supply of Westchester County communities. Shaft 1A North, constructed under a previous contract, will be available for prosecution of the future tunnel work; ultimately it will deliver Delaware aqueduct water to Hill View reservoir and to the city distribution tunnels.

The essential details of these shafts and the other shaft contracts are shown in Table No. 2. After the completion of tunnel construction, Shaft 4 will be equipped with risers and control works for interconnection with the Catskill aqueduct which crosses the Delaware aqueduct at this point. Shaft 5A will be equipped with a riser for the supply of adjacent communities; Shaft 6, with drainage equipment for unwatering the 45-mi. Rondout-West Branch tunnel and with a riser for the supply of adjacent communities. Shaft 11 will have built into it a down pipe to receive water from the adjacent Croton reservoirs and Shaft 13 will have both drainage equipment for unwatering the 22-mi. West Branch-Kensico tunnel, and a down pipe to receive water from adjacent Croton reservoirs. As previously stated all equipment will be installed under future tunnel contracts and nothing but the concrete lining will be included in the present work. Shaft 1, the intake and control shaft at Rondout reservoir, with its gate house and equipment will be built under later contracts.

Direction

The Delaware project will be carried out by the New York City Board of Water Supply—George J. Gillespie, Henry Hesterberg and Rufus E. McGahen, commissioners. The work will be under the engineering supervision of Walter E. Spear, chief engineer and Charles M. Clark, deputy chief engineer, with Thaddeus Merriman, Harrison P. Eddy, George A. Orrok and Frank E. Winsor, consulting engineers, Charles P. Berkey, consulting geologist, and York & Sawyer, consulting architects. Design will be under the supervision of Roger W. Armstrong, department engineer, headquarters department, and construction of the shafts under department engineers James A. Guttridge, watershed department, Shafts 1 to 5A, and Harry R. Bouton, eastern department, Shafts 6 to 23.

* For the long history of negotiation and litigation see EN-R, Apr. 3, 1924, p. 585; Dec. 11, 1924, p. 969; Feb. 5, 1925, pp. 219, 233; May 7, 1925, p. 785; Feb. 2, 1926, p 209; Jan. 20, 1927, p. 100; Aug. 11, 1927, p. 210; Jan. 26, 1928, p. 170; April 25, 1929, p. 681; Feb. 2, 1931, p. 284; May 7, 1931, p. 777; May 31, 1934, p. 698; Feb. 20, 1936, p. 297; Apr. 2, 1936, p. 506; June 11, 1936, p. 858.

Personnel Service Extended To Small Cities

EXPERT PERSONNEL PROCEDURES may now be installed in the cities of two states where the cities themselves are unprepared to support a full time public personnel agency. In California and Michigan, instead of supporting a civil service office individually, some cities are contracting for personnel services with outside bodies.

The Civil Service Assembly of the United States and Canada reports in its current news letter that Inglewood, California, city of 16,000, recently contracted with the Los Angeles County civil service commission to examine candidates for its police department. This is the second city in the state to take advantage of the special provision in the state laws that permits the county civil service commission to perform service to municipalities outside Los Angeles. Some time ago South Gate elected to participate in a similar contract.

Three Michigan cities—Flint, Dearborn and Saginaw—are now operating personnel systems established in cooperation with the Michigan Municipal League. The league has organized a staff of personnel technicians to render continuous operating services on a cost basis to these cities and to all members cities of the league. Under this plan cities that could not ordinarily afford to maintain staffs of specialists to examine applicants for jobs, to classify positions, to conduct in-service training programs and to perform the many tasks involved in modern personnel administration can pool their resources and get the services through the central agency of the league of municipalities at a cost that will be entirely within their means.

Developing High Efficiencies in Large Single-Stage Pumps

Laboratory tests raise design standards—A saving of $50,000 per year on Colorado River aqueduct pumping system for each 1-per cent efficiency increase—At least 92 per cent expected—Heads up to 476 ft.

By J. M. Gaylord
Chief Electrical Engineer, Metropolitan Water District of Southern California Los Angeles, California

THE AQUEDUCT that is being built by the Metropolitan Water District to bring a water supply from the Colorado River to cities of southern California is now in its fourth year of construction. The undertaking is to cost nearly twice the amount expended for Boulder Dam and must provide for conveying a dependable and continuous water supply across 242 miles of mountain and desert terrain to a terminal reservoir at Cajalco near the eastern end of the coastal area served. Flood waters of the Colorado River are to be stored in Boulder reservoir, released as required and allowed to flow down the natural river channel about 150 miles to the aqeduct intake at Parker Dam.

In order that water at Parker reservoir level may flow into the district's distribution system it must be lifted a total of 1,616 ft. and this is the function of five pumping plants located at advantageous points along the aqueduct. The fifth and last pump lift (126 miles from the aqueduct intake) is being built at Hayfield reservoir from which point the water will flow by gravity the remaining 116 miles to Cajalco reservoir. From Cajalco the 150 miles of feeders in the distribution system can be served by gravity.

The location and height of the several pumping lifts was fixed largely by the topography of the route selected. Distances, heads and motive power required are shown in the accompanying drawings and in Table I. When the ultimate capacity of the aqueduct is being delivered, which is not expected to be for a considerable time, the pumping requirement will be 300,000 kw. and the annual energy consumption will be 2½ million kw.-hr. A total cost of $33,000,000 for the pumping system and an annual operating expense exceeding $5,500,000 presented a problem in pump design worthy the most careful consideration.

American experience in the design of pumping plants comparable to those under consideration is extremely limited and European practice leaves much to be desired in operating efficiency. Manufacturers' recommendations differed greatly as to the best type and arrangement of pumps for meeting Colorado River aqueduct requirements and no two agreed on the more technical questions of specific speed, head per stage and maximum inlet pressure. This situation suggested that the district should make certain technical studies on its own account, a plan which was carried out with excellent results as will be outlined in the following.

The entire aqueduct design including the pumps is based on the district's right to 1,100,000 acre-ft. per year of the flow in the Colorado River which the U. S. Bureau of Reclamation has contracted to store in Boulder reservoir. This quantity is equivalent to a continuous flow in the aqueduct of 1,500 sec.-ft. However, an allowance of 7 per cent outage time for maintenance and repairs made it desirable to design the aqueduct for 1,605 sec.-ft. The capacity at each pumping plant is to be subdivided into nine units—eight for operation and one spare—all of 200 sec.-ft. capacity. The horsepower capacity of the motors will be 4,300 for the low head, 9,000 for the medium head, and 12,500 for the high head pumps.

Selecting a pump capacity of 200 sec.-ft. for the heads involved is a step in advance of American experience but is considered desirable for highest efficiency and best mechanical construction. Moreover, 200 sec.-ft. is a step of reasonable size for meeting the expected gradual increase in demand. Dividing the capacity at each plant into nine units, facilitates regulation of water delivery under the proposed plan for part time operation of each pump. At each plant there will be three 10-ft. steel delivery lines each branching at its lower end to connect with three pumps.

Numerous estimates on alternative designs clearly indicated that construction costs would be greatly reduced by adopting the vertical shaft pump and this type was selected. The use of single-stage pumps in the two high lift plants offered the possibility of large additional savings but in the absence of definite experience most of the designers feared that raising the head per stage to 450 ft. would reduce the efficiency to the extent of 1 per cent or more below that of a normal design. Since efficiency directly affects the power bill, an efficiency drop of 1 per cent in the pumping system would increase operating costs about $50,000 per annum. Thus the value of saving 1 per cent in efficiency can be capitalized at $1,250,000. Pump efficiency therefore became a matter of paramount importance.

Pump Laboratory Built

Pumping efficiency is affected by many factors, some dependent upon the skill and experience of the impeller and casing designer, and others dependent upon proper selection of type, speed and setting. In drawing up specifications for the purchase of pumps the latter factors were determined in advance in order that the bids would be on a uniform basis, but all possible latitude was left for the exercise of skill on the part of the manufacturers in the design of the hydraulic and mechanical features of the equipment to be offered. In 1933 the district undertook its part of the work by building a pump testing laboratory at California Institute of Technology in Pasadena and with the assistance of the institute staff began an intensive study of the problems involved. Testing preliminary to the preparation of specifications for the purchase of pumps was completed in 1935 and the testing of contractors' models was completed in the fall of 1936. The laboratory was laid out to give practical answers to the immediate and pressing problems of the district and the institute staff gave the work the able guidance of recognized authorities in scientific research.

The laboratory is designed for rapid, accurate testing of pumps up to a ca-

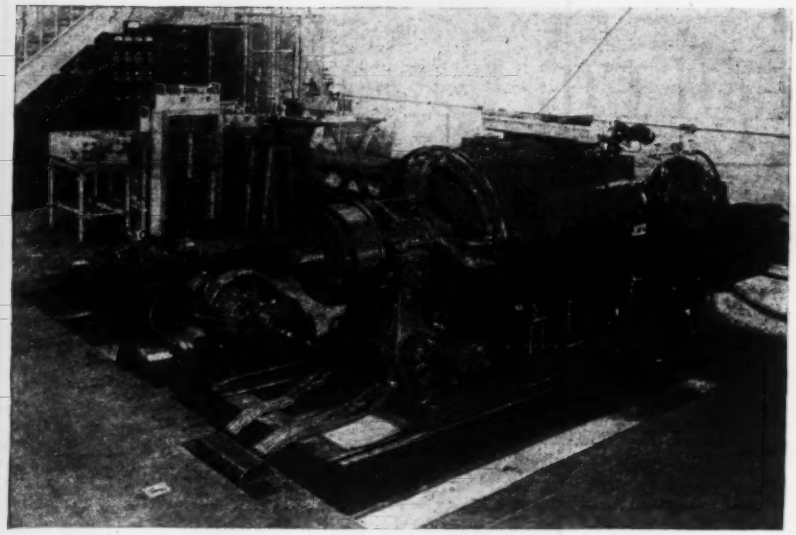


FIG. 1—TESTING DYNAMOMETER in the Pasadena laboratory. Pump under test at right, control panel in background.

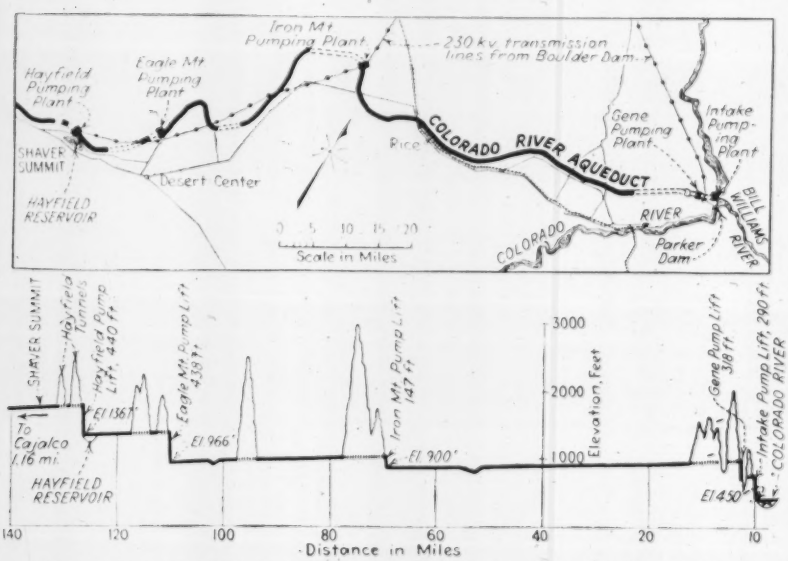


FIG. 3—THE PUMPING PLANTS are all located in the eastern half of the Colorado River Aqueduct.

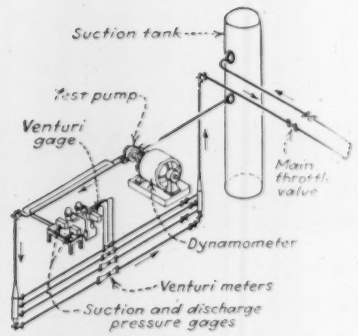


FIG. 2—PUMP TESTING DIAGRAM. The circuit followed by the water during tests is indicated by arrows.

pacity of about 10 sec.-ft. and 500 hp. under any desired inlet pressure and discharge heads up to about 600 ft. A direct-current cradle dynamometer is provided for driving the pump under test. This motor receives power from a motor-generator set installed for operating the wind tunnel fans in an adjacent laboratory and can be operated at speeds up to 5,000 r.p.m.

Constant speed which is so essential to accurate testing of centrifugal pumps is maintained by an ingenious device having as its source of constant frequency an oscillating quartz crystal similar to those used in controlling radio broadcast frequency. Through this device the test pump can be operated at any desired speed with speed fluctuations reduced to less than one part in 1,000.

A battery of Venturi meters arranged for frequent volumetric calibration provides accurate measurement of quantity and during tests the determination of discharge and inlet pressures is accomplished by pressure gages specially designed and constructed for the purpose. Venturi meter differentials are measured by precise weighing of mercury displaced in a specially designed U-tube. Inlet heads and discharge heads are determined by weighing fluid pressures against accurately ground pistons of known area. At each test point the instruments are automatically balanced by electrical contact devices operating motor-driven weights on the weighing scale arms and when equilibrium is attained the operator locks all instruments by de-energizing an electric circuit. A single observer then can record the readings with assurance that they represent truly simultaneous measurements of the various quantities. Analysis of the testing instruments as well as study of the results of several thousand tests indicates that, within the range of the testing capacity of the laboratory, pump efficiency can be determined with a precision well within 1/10 of one per cent.

The cooperation of several prominent pump manufacturers was enlisted in preparing high efficiency designs and six 8-in. test pumps were purchased covering single and double suction types with specific speeds ranging from 1,000 to 1,700. Several hundred tests were made using these models to solve the problems leading up to the preparation of specifications for the full size pumps.

Comparison of Models

A series of tests comparing single suction and double suction pumps failed to show superiority of either type in efficiency or other operating characteristics. The choice in favor of the single suction type was due to the simpler station design resulting from its use in the vertical shaft form. With this type of pump the setting resembles the familiar setting of a hydraulic turbine and permits the same favorable arrangement of water passages.

The use of single-stage pumps for the 452-ft. lift at Eagle Mountain and the 476-ft. maximum lift at Hayfield offered a definite saving amounting to several hundred thousand dollars in the first cost of these plants. However, this is a radical step in advance of past practice in the design of large centrifugal pumps where the maximum so far attempted has been less than 300 ft. Many tests were made in the laboratory of pumps having different specific speeds and produced by different designers to determine what loss of efficiency and other desirable operating characteristics might be expected from the adoption of the single-stage units. No material

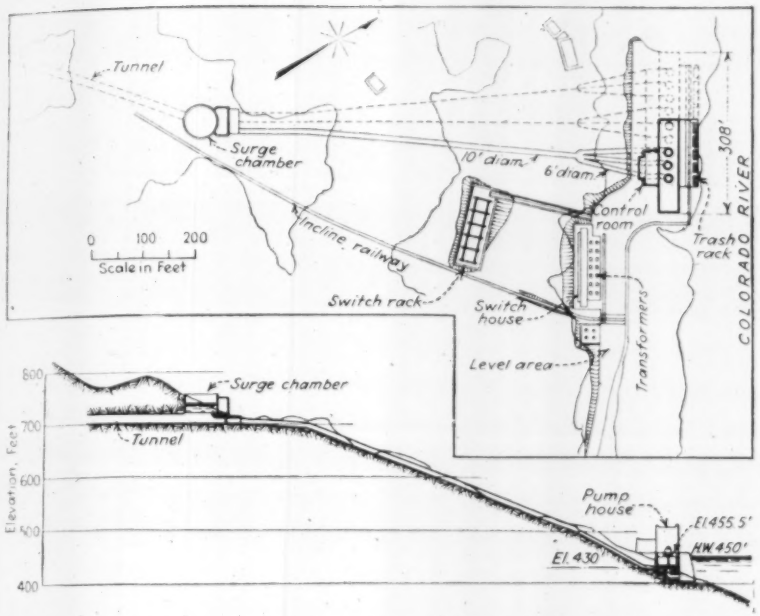


FIG. 4—THE INTAKE PUMPING PLANT is typical of the others of the series in the provision for expansion as demand on the aqueduct is increased.

sacrifice in efficiency was discovered and it was concluded that any possible difference in efficiency between 300 and 450 ft. per stage is less than the differences to be expected between the designs made by the best available talent in different factories. The results of testing contractors' pump models for the different lifts gave further confirmation of the accuracy of this conclusion.

The speeds originally proposed for the three lifts were 277, 300 and 360 r.p.m. respectively. Increasing these speeds offers the possibility of material saving in the size and cost of motors but increasing the specific speed increases the danger from cavitation caused by low pressures developed at the entrance to the impeller. This was investigated by testing the pumps of various specific speeds under normal and low inlet pressures. As a result the speeds were increased to 300 at Iron Mountain, specific speed 2,180; 400 at the medium head plants, specific speeds 1,650 to 1,700 and 450 at the high head plants, specific speeds 1,420 to 1,430. At these speeds a minimum positive inlet pressure head of 5 ft. was found to be sufficient to insure good operation and freedom from cavitation. Even higher speeds could have been used but the estimated cost of the deeper setting required more than offset the reduction in cost of equipment due to the higher speed.

Results of the tests

In many models, precise determination of head, capacity and efficiency at constant speed revealed irregularities in operating characteristics and unstable conditions of flow not detectable under ordinary test procedure. Such conditions were further investigated by means of a direction finding pitot tube inserted in the pump volute through axial holes just outside the periphery of the impeller. This device also was used to investigate flow and pressure conditions inside the pump during tests at low inlet pressures and under tests simulating the transient conditions encountered in the starting and in sudden stopping of the pump.

The tests at low inlet pressures were particularly useful in determining the depth of setting required to give stable operation. Instability of operation and cavitation result when the absolute pressure at the entrance to the impeller approaches the vapor pressure of water. These unfavorable conditions are prevented by deeper setting which increases the pressure at this point. Breaks in the test curves clearly indicate the starting of instability; all models were subjected to tests to determine their cavitation limits and best operating conditions.

During the transient conditions which occur while starting and stopping, it was found that the pump impeller is subjected to heavy side thrusts instead of the balanced load of normal operation. These forces were measured with a fair degree of accuracy. In many cases they were found to be sufficient to bend the pump shaft and cause contact of wearing rings. To prevent such contact with its resultant loss of efficiency the district's specifica-

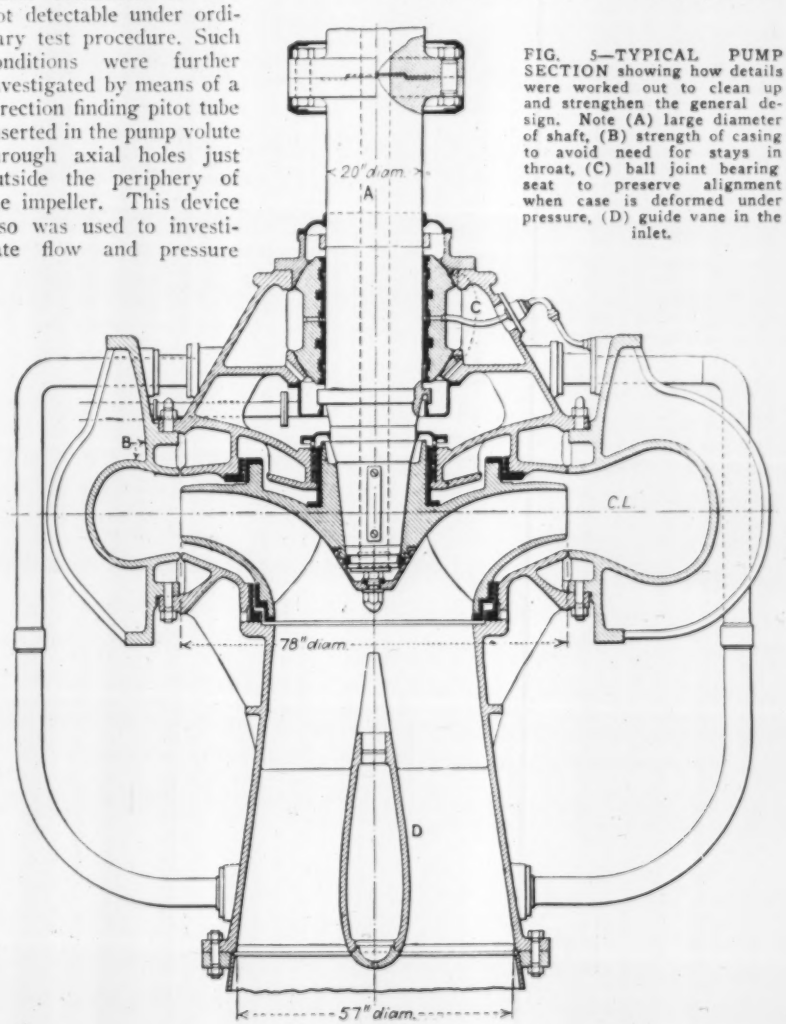


FIG. 5—TYPICAL PUMP SECTION showing how details were worked out to clean up and strengthen the general design. Note (A) large diameter of shaft, (B) strength of casing to avoid need for stays in throat, (C) ball joint bearing seat to preserve alignment when case is deformed under pressure, (D) guide vane in the inlet.

tions provide for shafts of unusually large diameter and stiffness.

The immediate savings in construction cost resulting from the testing program are conservatively estimated at $750,000 which is many times the cost of the laboratory and its operation. Additional savings will accrue as more pumps are installed in completing the plants. Undoubtedly the efficiency has been increased by the more exact knowledge of flow inside the pumps and by stimulating competitive designing effort. Better operation and better sustained efficiency is to be expected from the improvements in mechanical design based on the information obtained.

The district's specifications for pumps issued in 1935 require vertical, single-suction, single-stage pumps for all the plants. A minimum efficiency of 88 per cent is specified and a bonus

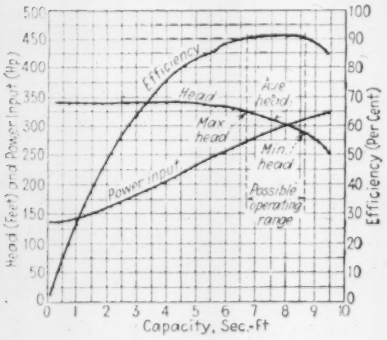
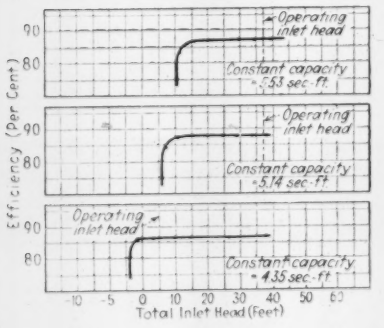


FIG. 6—TYPICAL CHARACTERISTICS of 8-in. pump models submitted for test by manufacturers. Tests were run at 2,133.5 r.p.m.

FIG. 7—TYPICAL CAVITATION CURVES for pump models showing inlet pressure limits below which serious cavitation occurs.



aggregating $55,000 for each per cent is offered for field test efficiency in excess of that guaranteed by the manufacturer. Each bidder was required to demonstrate his ability to meet the specifications by submitting with his bid for test, a 1 to 6.3 scale model of the highest head pump included in his bid. All models submitted were for the Hayfield pumps. One model failed

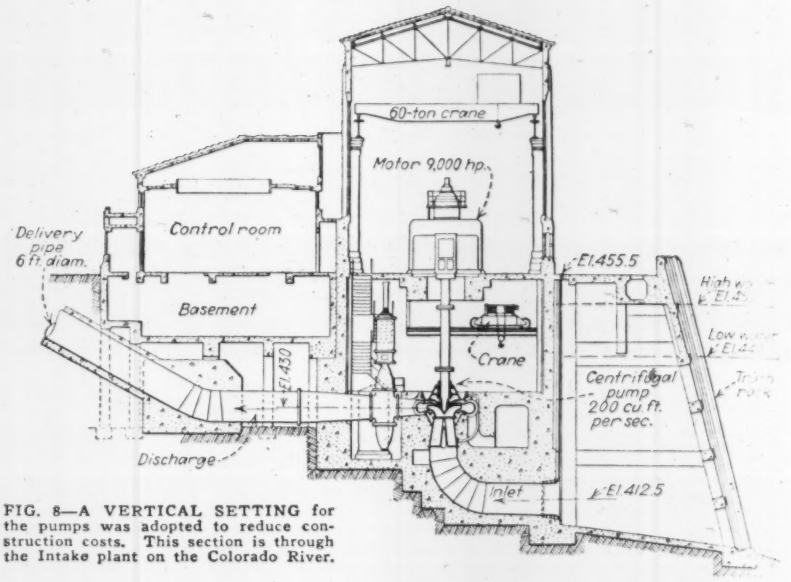


FIG. 8—A VERTICAL SETTING for the pumps was adopted to reduce construction costs. This section is through the Intake plant on the Colorado River.

to meet the requirements. The best efficiency shown by any model was 89.6 per cent.

High efficiencies expected

Contracts were awarded to three prominent pump manufacturers and each has submitted for test a model representing the pumps he is to furnish. These models having a linear scale ratio of approximately 1 to 5.3, all show efficiencies of approximately 91.5 per cent. Materially higher efficiencies are to be expected in the full sized pumps which are to be tested after installation. These results are believed to represent a distinct advance in the art since the best large European pumps are reported to have efficiencies from 84 to 86 per cent and there is only one authentic record of a comparable American pump giving an efficiency over 90 per cent.

No movable vanes or other means of regulating pump discharge are employed. Simplicity of design is thus retained. Regulation of quantity delivered is accomplished by varying the period of operation. The design of the aqueduct with its storage reservoirs makes this method of operation permissible and the supply of power from Boulder Dam is not restricted by peak and load factor penalties that would increase operating cost under the conditions of irregular demand. As a means of equalizing any possible differences between the flow in the aqueduct and the capacity of the pumps in operation, artificial regulating forebays of 100-acre-ft. capacity are provided at Iron Mountain and Eagle Mountain where no natural reservoirs were available. These basins will be helpful in avoiding too frequent starting and stopping of pumps and will provide rejection storage when operation is interrupted.

The pumps will be started with the casings full of water, the inlet valve open and the discharge valve closed except for a bypass to permit the discharge of sufficient water to prevent overheating. Full voltage will be applied to the motor, and acceleration will be rapid. As soon as approximately full speed is attained the motor will be synchronized and the discharge valve slowly opened. In taking a pump out of service during normal operation the discharge valve will be closed before the power is cut off from the motor. The inlet valve to the pump is always open except when a pump is to be unwatered. A single stop valve in each pump discharge connection is to be operated by oil pressure under automatic control similar to that used in hydraulic turbine governor practice.

Transient conditions studied

The transient conditions in starting and stopping pumps, particularly when failure of the power supply causes a sudden shutdown, were thoroughly investigated by model tests in the laboratory. Such conditions tend to produce pressure waves, reverse flow and reverse rotation of pumps which may be dangerous to the pipe lines and equipment if not properly controlled. The laws of water hammer are well established and can be calculated. Practically all of the other transient condition were reproduced in the laboratory and maintained for a sufficient time to determine their effect on the equipment. When power fails the discharge valve will be closed by oil pressure from an accumulator tank, the timing of which is so adjusted that the return flow from the delivery pipe will

start but will not attain a dangerous velocity. The return pressure wave is thus relieved by backward discharge through the pump and the problem of checking the back flow without excessive pressure rise becomes the familiar one which has been satisfactorily solved in hydraulic turbine practice. The installation is designed to limit the pressure rise under all probable conditions to 50 per cent above normal in the highest head plants and to 125 per cent above normal in the Iron Mountain plant where the static head is 146 ft. At these maximum pressures the stresses in the steel pipes will not exceed 20,000 lb. per sq.in.

The discharge pipes are of steel 800 to 2,000 ft. long and 10 ft. in diameter with a plate thickness of $\frac{3}{8}$ in. to $1\frac{1}{8}$ in. They will be supported above ground on concrete piers about 40 ft. apart, with anchors at each angle point and expansion joints between. All longitudinal seams and all shop girth joints are arc welded, stress relieved and radiographed. All field joints are riveted with rivets countersunk on the inside.

At Intake, Gene and Iron Mountain plants the delivery pipes connect with tunnels which will operate as closed conduits under slight pressure. At the junction of the delivery line with the tunnel in each plant a surge chamber is provided to take up oscillations resulting from sudden stoppage of the pumps. For similar reasons a surge chamber is provided on the conduit leading from Gene reservoir to Gene pumping plant.

The pumps will be direct connected to 6,900-volt, synchronous motors with main and pilot exciters mounted on the motor shaft. The motors are totally enclosed for recirculation of air and water cooling. A CO_2 fire protection system will be provided. Each station except Intake ultimately will be equipped with two banks of water cooled transformers receiving power from the 230-kv. transmission line and stepping it down to motor voltage. The transformers at Gene are to be equipped with three windings and will furnish power at 69 kv. for transmission to Intake as well as 6,900-volt power for operating the motors at Gene. The first installation at each plant will consist of one bank of transformers with necessary spares.

Comparative figures for the five pumping plants, given in Table I, are for equipment specified in contracts awarded Feb. 8, 1936. In each case the initial installation is three 200-sec.-ft. pumps and one delivery pipe; the ultimate installation in each plant will be nine pumps. The initial installations now are under way at each of the five pumping plants. The additional units will be added as the demand for water increases. The pumping plant buildings and the pipe lines are all being built by contract but installation of equipment will be done by district forces.

F. E. Weymouth is general manager and chief engineer of the Metropolitan Water District of Southern California. The design and construction of the pumping system is under the supervision of the author. R. M. Peabody, mechanical engineer, has directed the laboratory work for the district. W. F. Durand is the principal consultant on the work. The laboratory at Pasadena is under the direction of Th. von Karman; assisting him in the investigations are Professors R. T. Knapp and R. L. Daugherty.

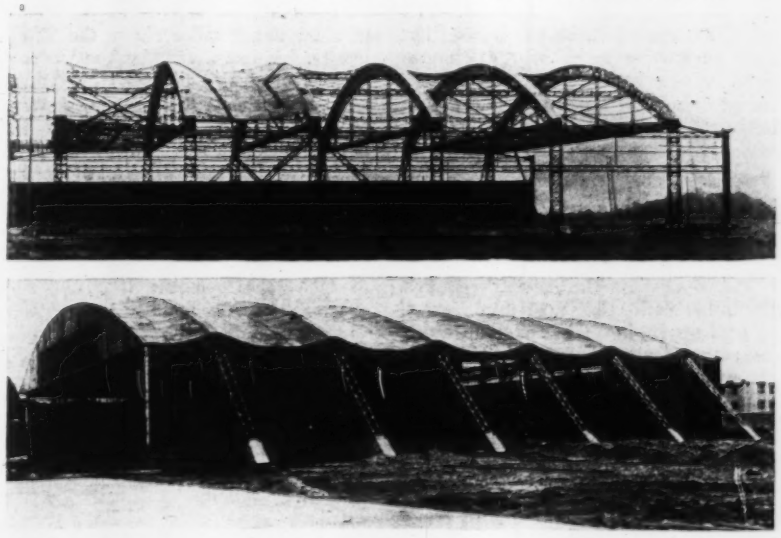
All-Steel Hangars in France Have Suspended Plate Roofs

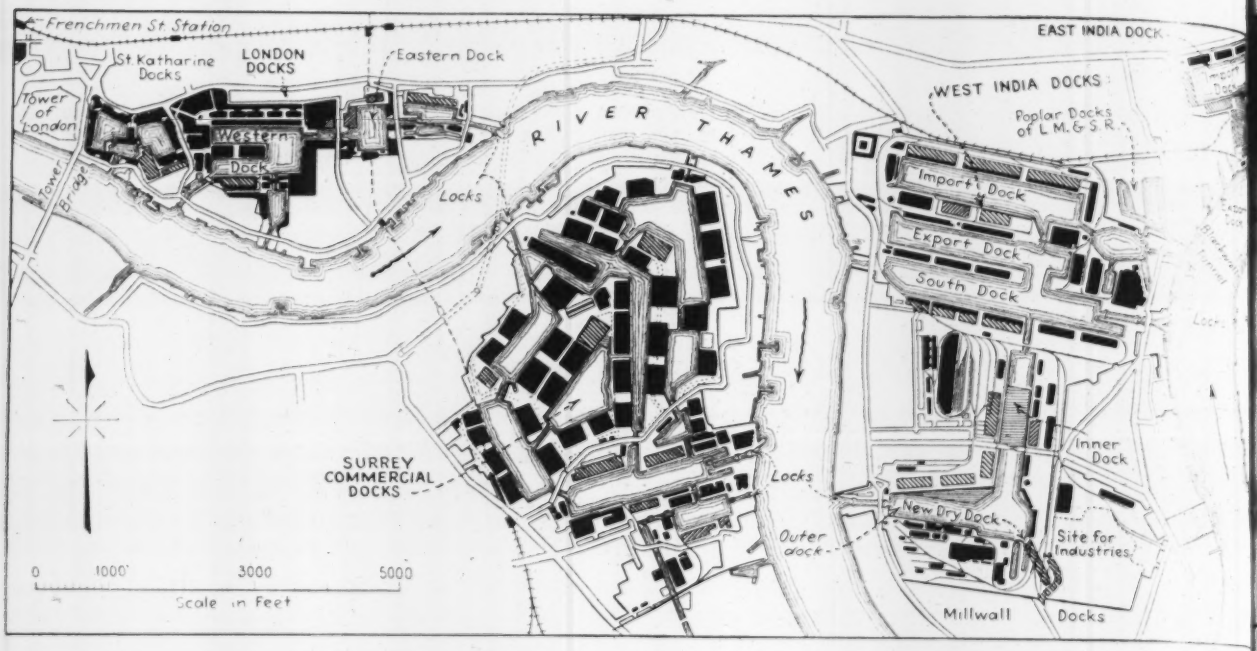
AT A NUMBER of French airports, hangars of a new type with steel frame, walls and roof, have recently been erected. Their principal distinguishing element is a suspended plate roof, but their framing is also unconventional. An article in the July-August, 1936, issue of *L'Ossature Metallique* (Brussels, Belgium) describes the new hangars in detail, emphasizing particularly their military advantages of quick erection and of ease of dismantling for re-use.

The hangar illustrated is at the Toulouse-Francazals airport and differs from others only in length, which is a multiple of the bay spacing of 36 ft. The Toulouse-Francazals hangar of 230 ft. span is 216 ft. long, made up of five 36 ft. bays with two 18 ft. bays at each end. Each of the six bents, exclusive of those in the end walls, is composed of a tied arch resting on pin-connected columns 32 ft. high and braced at one side by an inclined strut placed outside the building. The strut braces the bent against wind loads brought to it by the walls and roof. The unbraced column at the opposite end of the bent is free to move under temperature and live loads. The tie is supported from the arch by five suspenders. Longitudinal bracing struts between the bents are placed at the tops and bottoms of these suspenders. All members, including the ties, are of rectangular sections built up of angles and lacing. The end wall bents are similar but of a lighter construction.

The roof plates are riveted to one another and to the roof arch ribs and function as suspended members. They are of high strength steel about 7/16 in. thick. The walls, up to a height of about 20 ft., are of similar steel plate pressed into channel sections for stiffness. An apron plate is used just below the roof, and the remainder of the wall space is filled in with steel sash. The hangars, known as Jeumont-Daydé type, are a product of Forges et Ateliers de Constructions Electriques de Jeumont, of Paris.

FRAMEWORK and completed hangar of suspended roof type as built in France.





London Port Improvements To Cost Sixty Million

Four-year program calls for widening and deepening of present docking areas, additional quays and numerous warehouses and transit sheds—Provision made for large new docking areas

WORK is now under way at London, England, on a program of port improvements and developments extending from 1936 to 1940 and estimated to cost $60,000,000.

In 1909, the various independent dock systems were amalgamated as the Port of London, under the management of the Port of London Authority. The several groups of docks are located between successive loops of the Thames River, which arrangement gives convenient access both upstream and downstream, as shown in Fig. 1. The Tilbury Docks are not shown as they are 16 miles downstream from the Royal Docks group. There is a tidal range of 20 ft. in the neighborhood of the docks, with an ebb and flow current of 2 to 3 m.p.h. The size and extent of the docks in the several groups, beginning with the upstream group, is indicated in the accompanying table; the depth at entrance is from high-water level to center of sill. The docks are connected with the railways and the arterial road system. To meet the needs of motor transport, the approach roads to the Royal Dock group have been reconstructed, largely on viaducts and bridges, at a cost of about $12,000,000. This work, described in *ENR* of July 23, 1936, page 111, was completed in 1935.

Among the works executed by the Port of London Authority (totaling more than $100,000,000) has been the dredging of the river, so that there is now a channel 1,000 ft. wide and 30 ft. deep at low tide from the estuary to about eight miles above the Tilbury Docks. Above that point the width decreases gradually to 500 ft. width and 14 ft. depth at the entrance to the St. Katherine Docks, which is sufficient for vessels of 6,500 tons gross register. Vessels 37 ft. draft have used the King George V dock, 40 miles inland. The net registered tonnage of vessels (arrivals and departures) has increased from 38,500,000 tons in 1909 to 60,500,000 tons in 1935, in which year the goods handled amounted to 41,000,000 tons. The annual value of the overseas trade is now about $2,200,000,000 or 33 per cent of the total overseas trade of the country. Further increases are anticipated when world trade becomes more normal.

In view of these conditions, the Port of London Authority has decided to enter upon a comprehensive scheme of improvements estimated to cost about $60,000,000, to be completed in 1940. Since the existing docks are favorably located it was desirable to improve and modernize them rather than to build new docks. These improvements include constructing quays to replace jetties, widening existing quays, deepening berths, rebuilding transit sheds and warehouses, building dry docks, and providing electric cranes and equipment which, in many cases, will replace hydraulic cranes. To avoid excessive interference with the working of the docks the program is divided into six stages. Particulars of some of the more important works are given below:

St. Katherine and London Dock Groups—Reconstructing bridges over two connecting channels, building two new quays and six sheds and warehouses of two to five stories.

Surrey Commercial Dock Group—Widening two connecting channels to accommodate large vessels in the timber trade, necessitating reconstruction of the bridges; rebuilding two quays and building nine sheds and warehouses of one to five stories.

West India Dock Group—Reconstruction of six-story warehouses at the Import Dock, with construction of a 25-ft. quay for 1,900 ft. along the south side to straighten the water front. This dock will be dredged to 29 ft. of water. As the warehouses on the north side are 130 years old they are obsolete, though still in good condition. At the South Dock, three six-story warehouses, with one-story transit sheds on the quay side, will replace obsolete structures.

Millwall Dock Group—At the Outer Dock, the quay wall will be set back

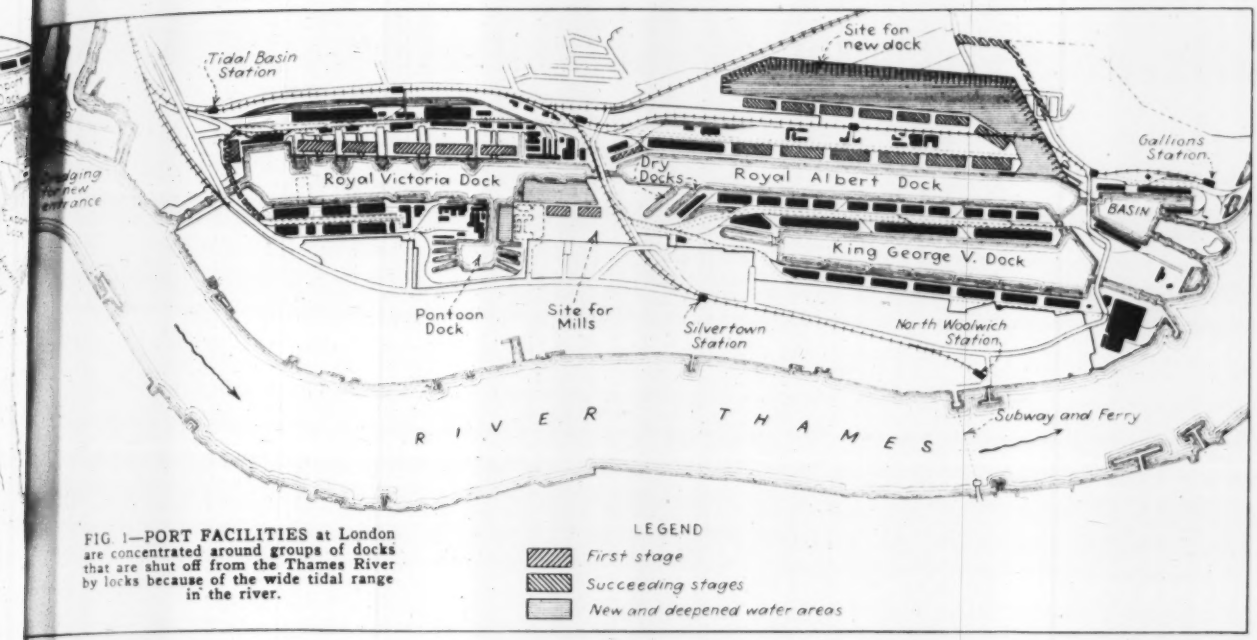


FIG. 1—**PORT FACILITIES** at London are concentrated around groups of docks that are shut off from the Thames River by locks because of the wide tidal range in the river.

and a triangular strip dredged to add 7½ acres of water area. The Inner Dock will be dredged to 29 ft. instead of the present 24-ft. depth. A new dry dock will accommodate larger ships. Five two-story transit sheds will be built, with wider quays, electric cranes and improved road and railway approaches. A vacant site of 40 acres will be graded to quay level for industrial development.

East India Dock Group—The two connected docks with separate small entrances will be converted into one L-shaped dock with a single large entrance from the river. There will be 15 acres of dredging, 3,300 ft. of new quays, 2,000 ft. of dock walls and five three-story warehouses with electric crane equipment.

Royal Dock Group—In the Royal Victoria Dock, the eight jetties projecting from the north side will be shortened and the remaining portions built into a new quay 3,250 ft. long, supported on piles or cylinder caissons. Five new three-story transit sheds, 504x150 ft. each, will have electric crane equipment. A new movable bridge for road and rail traffic will be built over the western entrance lock. Work nearly completed on the south side of this dock has included removal of a jetty separating it from the Tidal Basin and the construction of 1,750 ft. of quay, with a large three-story warehouse of reinforced-concrete.

The narrow southeast corner of the Royal Victoria Dock is being dredged to add 10 acres of water area and 2,300 ft. of new quay, with two three-story sheds. About 24 acres of ground are being excavated to quay level to provide sites for mills. In the Royal Albert Dock, more than a mile of the north quay has been widened to 59 ft., with 34 ft. of water, and five-story sheds will replace the present one-story structure. No work is scheduled for the King George V Dock, which was opened in 1921 and is the newest of all the docks. Alterations to two railway tunnels under the channel connecting the Royal Victoria and Royal Albert docks were made necessary by the 4½ ft. deepening of the channel. After lining the tunnels with steel segments, electrically welded, the crown of the brick arch was demolished by divers.

CHARACTERISTICS OF LONDON DOCKS

Dock Groups	Total Area	Water Area	Principal Entrance			Quays
			Length	Width	Depth	
	Acres	Acres	ft.	ft.	ft.	Miles
St. Katherine and London	123	45	350	60	28	4
Surrey Commercial	381	134	550	80	35¼	8¾
West India and Millwall	467	133½	590	80	35	6¾
East India	67	31½	300	80	31	1¾
Royal	1,102	247	800	100	45	12¾
Tilbury	725	104	1,000	110	45½	4

Provision for a future new dock with a water area of 63 acres, 10,000 ft. of quay and seven warehouses, has been made by reserving a site north of the Royal Albert Dock, but this work will not be commenced until increased trade necessitates it.

Tilbury Dock Group—Here the floating landing stage, available for the largest liners at any stage of the tide, will be extended 450 ft. to a total length of 1,592 ft. At the western entrance to the main dock, the south wing wall will be removed to facilitate vessels entering and leaving at ebb tide. Access roads will be improved.

FHA Conferences Discuss Sites for Low-Priced Homes

WITH THE PURPOSE of stimulating interest among lending institutions, builders, and real-estate men in the creation of decent areas for low-priced homes, the Federal Housing Administration is holding a series of land subdivision conferences in a number of cities. Such conferences have already been held in Detroit, Chicago, Cleveland, Washington, Boston, Newark, St. Louis, Milwaukee, and Kansas City, Mo. Among the fundamental considerations in determining a proper site are the topography, soil, accessibility to schools, employment, and shopping centers, availability of appropriate utilities and street improvements, zoning protection, and proper correlation between taxes and assessments. Conclusions that can be drawn as a result of these conferences, according to Seward H. Mott, chief, land planning section, Federal Housing Administration, are:

That there is increasing recognition on the part of the lenders of the importance of the physical security behind the mortgage.

That developers and builders are showing increasing interest in the production of houses for the mass market.

That there is a realization by both buyer and lender that the small house, if well located and built, provides a high quality of security.

Welded Design for Six-Span Continuous Girder Bridge

On new highway structure at Perade, Quebec, girders are continuous over six 107-ft. spans and floorbeams are made continuous through the girders

By D. B. Armstrong
Dominion Bridge Co., Ltd.
Lachine, Quebec

THE NEW HIGHWAY BRIDGE across the Ste. Anne River at the village of La Perade, P. Q., on the main highway between the cities of Montreal and Quebec, officially opened to traffic on October 25, is an all-welded structure consisting of six continuous deck girder spans of 107 ft. which replace three pin-connected through truss spans of twice that length built some 40 years ago. The continuous girder design, providing minimum depth at the span centers and a pleasing arch form between the piers, was chosen as best meeting the two fundamental requirements—maximum possible water clearance, to pass floods, and a freedom from overhead obstructions, so that the view of the impressive parish church at one end of the bridge would be unimpaired.

Although it was necessary to replace the old superstructure because of obsolescence, the original substructure, of limestone piers and abutments founded on timber piles driven to a good depth, was still in an excellent state of preservation, and considerable economy was gained by re-utilizing it in the design of the new bridge. The old piers and abutments were cut down about 7 ft. and capped with reinforced concrete, to accommodate the new plate girders, and three additional piers were introduced in the centers of the old spans.

The river bottom at the bridge site consists of fine sand, with minor traces of clay, to an explored depth of 40 ft. During floods severe scouring of the river bottom occurs, but the old timber cofferdams surrounded by stone rip-rap had provided ample protection, and after a period of 40 years there was no evidence of settlement or undermining of the old piers. Consequently, a similar design was chosen for the new piers.

Cofferdams of steel sheetpiling, 30 to 35 ft. in length, were driven and unwatered, and the sand excavated by hand to a maximum depth of 17 ft. below water level. Infiltration of water through the sand bottom was negligible. About 48 timber piles, 25 ft. long were driven for each pier, and the bottom seal of concrete was poured practically in the dry.

Pier construction commenced in January, so that operations could be carried on from the ice. An unexpected early break-up of the ice caused some construction difficulties, including scouring of the river bottom to an additional depth of 14 ft. (nearly to the bottom of the sheet piling), tilting of one of the cofferdams and the loss of the old bridge spans which had been transferred to temporary timber bents, to serve as a detour. Brush mats and rip-rap repaired the scour damage, the tilted cofferdam was brought back to position without great difficulty, and a new temporary trestle bridge was built after the flood waters subsided.

On completion of the piers, the sheetpiling was driven to refusal and the tops burned off at low water level. Additional riprap of heavy stone was placed on all sides of the piers subject to erosion.

The bridge was designed to the C.E.S.A. specifications for highway bridges for class U-100 loading with 20-ton trucks. The deck provides a 24-ft. clear concrete roadway with asphalt surfacing and two 5-ft. sidewalks protected by ornamental steel fences 4 ft. high. The roadway slab, 7 in. thick and reinforced with longitudinal bars, is carried on transverse floorbeams spaced on 9 ft. centers. The 4-in. sidewalk slab spans between the roadway curb and a longitudinal concrete fascia girder, 17 in. deep by 6 in. wide which is carried on the cantilevered ends of the floorbeams. These floors beams, 34 ft. long are 21-in. 591 lb. sections, framed flush with the tops of the main girders which are spaced at 8-ft. centers. The floorbeams

FIG. 2 — FLOORBEAM - GIRDER JOINT and sidewalk railing of Perade Bridge

FIG. 1—SIX CONTINUOUS WELDED SPANS comprise the new Perade, Quebec, bridge. The piers are alternately new and old, the latter having accommodated through trusses of twice the span length used on the new bridge

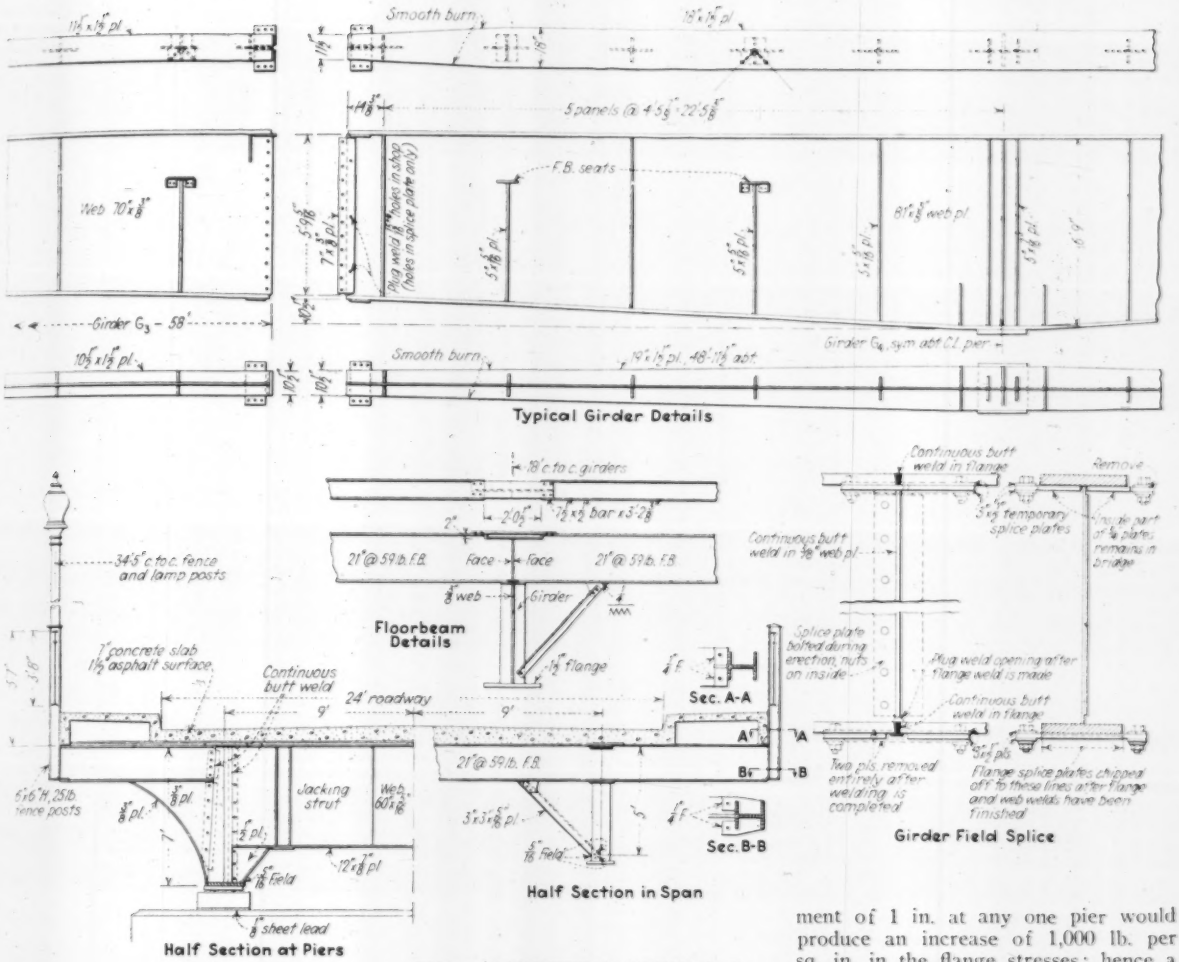


FIG. 3—STRUCTURAL DETAILS of all-welded continuous girder bridge

are cut at the girders and are faced to bear against the girder webs, while the top flanges are connected by tension plates passing over the girder flanges. The girder stiffeners at these points are cut short and capped, to provide erection seats for the floorbeams.

The main girders are built up plates, $\frac{3}{8}$-in. for the webs and $1\frac{1}{2}$-in. for the flanges, the latter varying in width from $24\frac{1}{2}$ in. at the piers to $10\frac{1}{2}$-in. at the mid-span points, according to the bending moment requirements. The girders are 7 ft. deep at the piers, $6\frac{1}{2}$ ft. at the abutments and $5\frac{1}{2}$ ft. at the span centers. The top flanges parallel the vertical curve of the roadway, which is parabolic with a 2-ft. rise at the center of the bridge. The girders were cambered by adjusting the outline of the web plates to compensate for the deflection of the girders under full dead load. Field splices are located close to the points of zero dead load bending moments, with the result that the maximum flange stress in the welded joints is less than 6,000 lb. per sq. in. from live load.

In designing the girders they were first computed as for six continuous spans of constant moment of inertia. After approximate trial sections had been obtained, the flange areas were weighted to compensate for the variable moment of inertia, and the stresses computed by more exact methods. The influence of the variable moment of inertia was to increase the maximum bending moments at the piers by about 12 per cent, with a corresponding decrease of 4 per cent in the end span, and 15 per cent in the second and third spans.

Designs for simple girder spans and for riveted continuous spans were also investigated. The estimated weight of the continuous welded girders was 85 per cent of the simple-span welded girders and also 85 per cent of the continuous riveted girders, so that the adopted design showed an apparent saving in weight of about 27 per cent as compared to simple-span riveted girders. Additional savings resulted from the elimination of extra floorbeams, fence posts and floor expansion joints over the piers required for simple span layouts.

Investigation showed that a settlement of 1 in. at any one pier would produce an increase of 1,000 lb. per sq. in. in the flange stresses; hence a settlement of 12 in. would have to occur before the minimum yield point of 30,000 lb. per sq. in. in the steel would be reached, and considerably more than that if only dead load stresses are considered. Levels were taken at all piers, before and after the superstructure was built, and no settlement under the full dead load of the spans could be detected.

The girders are supported on fixed shoes at the center pier and on 8-in. diameter segmental rollers at all other points of support. At each pier and abutment the transverse floorbeams are replaced by deep girders which not only serve as brace frames but also constitute permanent struts for jacking the main girders off their bearings, if this should ever be necessary. Inclined angle braces, between the floorbeams and bottom flanges of the main girders, are located at every floorbeams where the flanges are in compression and at every second floorbeam where they are in tension. The concrete roadway slab which rests directly on the top flanges of the girders insures adequate lateral stiffness, and only light temporary diagonal bracing was supplied for aligning the girders during erection.

To facilitate the fabrication of the

curved girders, tangent working lines were established for each span, and all floorbeams, stiffeners and splices were located normal to these lines excepting the details directly over the piers, which are vertical. Offset from these lines established the profiles of the web plates, which were cut to shape with oxyacetylene torches. The location of all stiffeners and lengths of welds were marked on the web plates by means of stencils. After the stiffeners were welded, the webs were set upright and assembled with the top and bottom flange plates; lugs previously tack welded at frequent intervals along the flange plates served to center the web plates during the assembling and tacking.

Continuous 5-16-in. fillet welds were used, and work proceeded simultaneously from the center toward the ends and on both sides of the web plates. The welding was alternated between the top and bottom flanges, to prevent distortion; this procedure also necessitated turning the sections over frequently, to permit all welding to be done downhand. After all welding of details had been completed, the semi-finished girders were laid on trestles and aligned between two accurately spaced parallel heads. These heads served as guides from which lines parallel to, and a fixed distance from, the splices were scribed on the girders by means of a trammel. The ends of the flanges and web plates were then accurately flame cut and chipped to the proper welding bevels. All splice plates were located from the splice lines by means of jigs, and tack welded in position preparatory to final welding.

The accuracy of the work was shown when adjoining girder sections were shop assembled and the main working line found to be less than 1-16 in. off line at the splice. Only sufficient splice material and connection details were provided to insure proper assembly of the component parts in the field and to take care of the erection stresses.

The work in the field

The spans were erected by a traveler running on temporary timbers laid across the floorbeams. Pile bents were driven, where necessary, to support the outer ends of the girders, and the main splices were brought together by drift pins and held by turned bolts, to obtain accurately matched joints.

Field welding was delayed until after 4 spans had been completely assembled and the fences plumbed. The type of structure and the location of the welds were ideal from the welders' viewpoint. The details were designed so that all of the welding was downhand and readily accessible. Light welded frames suspended from the floorbeams supported scaffolds from which the girder web and bottom flange could be reached. These frames were ladder-like in form, to accommodate the scaffolding at different levels.

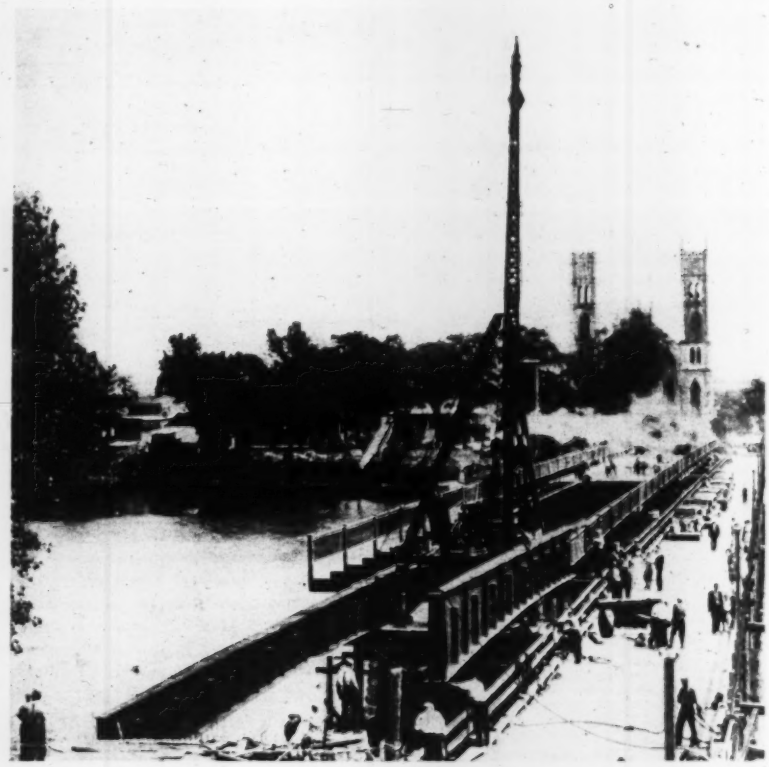


FIG. 4—ERECTING LAST GIRDER in Perade Bridge. Temporary trestle bridge is at right and the parish church in the background

Four electrically driven, 300-amp. welding units were used for the work, and 8 operators were employed for approximately 4 weeks, working in double shifts of 9 hr. each. The average amount of metal deposited per hour was 1.3 lb. per operator, which compared favorably with the average rate of 3.0 lb. per hour in the shop.

After the splice welds had been completed, the outstanding edges of the splice plates were burned off, and the bottom flange splice plates were removed entirely, by chipping out the weld metal which connected them to the flanges. All bolts were removed from the web splice plates and the holes were filled with plugs, welded in place, and chipped flush for apearance.

The cost of the field welding compared favorably with the estimated cost of riveted work, being slightly higher on a straight tonnage basis but approximately equal when allowance is made for the heavier weight of a riveted structure. The total weight of structural steel in the bridge amounted to 318 tons, of which 183 tons represents the main girders. The amount of covered welding electrode used was 6460 lb. in the shop and 1780 lb. in the field.

The superstructure was fabricated and erected by the Dominion Bridge Co., Ltd., Lachine, Quebec, which was also the general contractor. Gauthier & Julien, Port Neuf, Quebec, was awarded the subcontract for the substructure and the roadway deck. The Atlas Asphalt Co., Montreal, supplied and laid the asphalt surfacing. The work was supervised by L. F. Gaboury on behalf of the parish of Ste. Anne de la Perade and the village of La Perade, joint owners of the bridge.

Housing Vacancies Decline in Many Cities

A SURVEY of almost 60,000 apartments in the Chicago area shows a general vacancy of 4.3 per cent, which represents a decrease of almost 2 per cent from last year's figure, according to Coleman Woodbury, executive director, National Association of Housing Officials. In Aurora, Ill., a manufacturing and railroad city of over 50,000 population on the edge of the Chicago metropolitan area, an inventory revealed that only 3.5 per cent of the houses were vacant. Residences renting from $30 to $75 and up a month were about 2 per cent vacant; those from $20 to $30, 2.7 per cent; those from $10 to $20, 5.5 per cent; and in the very small class of houses renting for less than $10 a month there was a 10.1 per cent vacancy. A similar survey in Pittsburgh showed a decrease in vacancies of 4 per cent during the past two years. There was a 3 per cent decline in owner-occupancy from February, 1934 to June, 1936, whereas tenant occupancy increased by more than 10 per cent.

Skew Roadway on a Right Angle Frame

Structure proposed for railroad grade crossing in New Jersey avoids complications of skew design but requires special reinforcement and small triangular slab extensions at two corners to support the ends of the roadway

By M. Hirschthal
Concrete Engineer
D. L. & W. R. R., Hoboken, N. J.

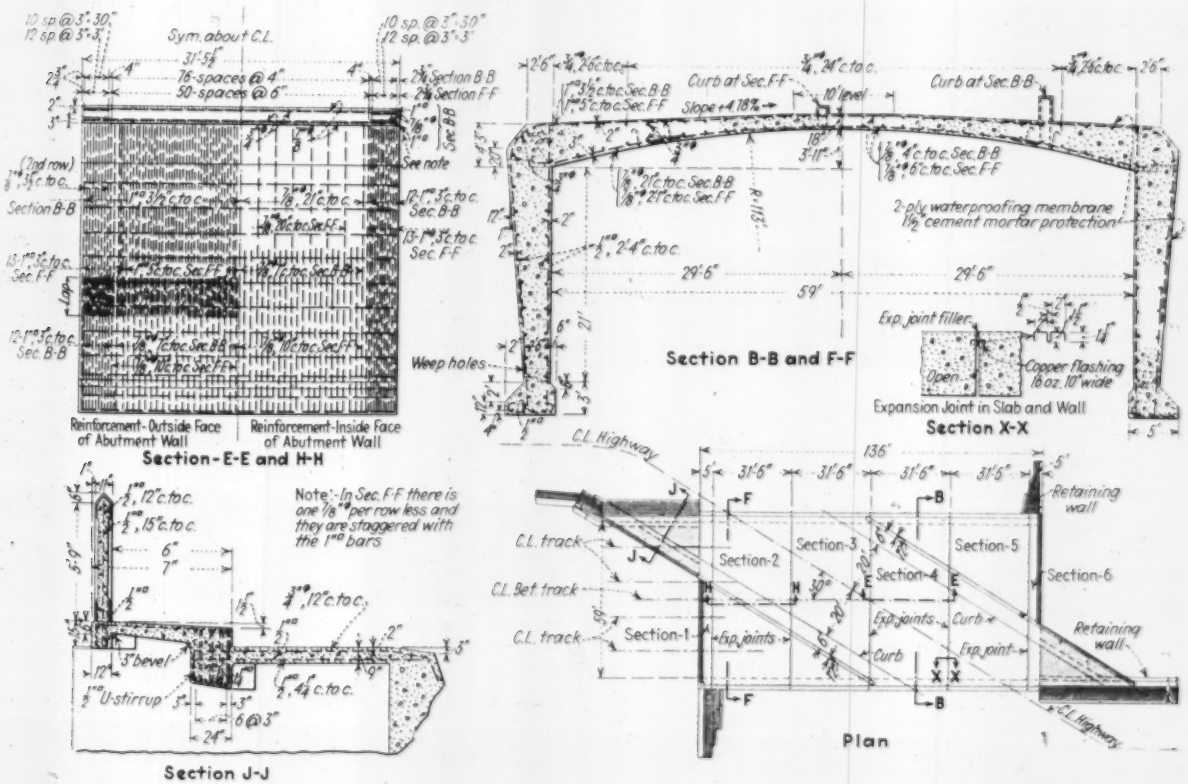
THE BRIDGE which is the subject of this article is proposed to replace a concrete elliptical arch built in 1909 when speeds of vehicles were low, so that a right angle crossing, with right angle turns joining roads parallel to and on either side of the railroad tracks, was not objectionable. The proposed structure is also a right angle frame with respect to its abutments, but it carries a roadway on a 60 deg. skew. This unusual arrangement furnishes the necessary sight distance for vehicles and is a skew crossing in fact, without the evils of skew construction or the difficulties of skew stress analysis that are involved.

The crossing location, one-half mile east of the Towaco, N. J. station on the Boonton Line of the D. L. & W. R. R., is a rock cut about 60 ft. wide accommodating four tracks. Three types of bridge were considered for the new structure: a through girder steel structure, a rigid frame skew arch bridge of reinforced concrete, and a structural steel ribbed frame. The available floor depth, giving consideration to a 22 ft. overhead clearance over the two main (inside) tracks, is 3 ft. from clearance point to the crown of the road. The clear span on the 60 deg. skew is 118 ft. so that center to center of bearings results in a span length of about 130 ft., which, for a 40 ft. roadway, requires at least a 44 ft. spacing of girders to provide brackets for lateral stability. The result is very expensive shallow construction for the floor system (with excessive center deflection); adding thereto the costly girder construction, the estimated cost was found to be prohibitive. The long span and shallow depth available also ruled out the skew concrete arch and the ribbed steel types, so that it appeared that a solution at a reasonable cost would be impossible. At this point it became evident that a modified right arch using skewed corners would solve the problem.

This method had, in fact, been considered as far back as 1921 in connection with a remodeling of the existing bridge; that is, it was proposed to add triangular sections to the arch bridge at the diagonally opposite corners permitting the installation of a skew roadway on the right angle frame. A design similar to that described below had been used last year by the New Jersey state highway department for a 33-ft. span over the Lackawanna tracks and no difficulty had been encountered. The feasibility of the design, therefore, was not in doubt.

The layout suggested for the Towaco crossing consists of sections of rigid frame arches designed for a span at right angles to the railroad tracks, with

STRUCTURAL DETAILS of a skew roadway crossing on a right angle frame.



end sections of ribs to support the ends of girders carrying the triangular sections of the roadway and overhanging sidewalks and supported at the other ends by the retaining walls necessary for holding the highway fill beyond the abutments.

As shown in the accompanying drawing, the structure, an arch barrel type of rigid frame, spans four tracks 13 ft. on centers with 10 ft. side clearance at the abutments, giving a 59 ft. clear opening. The soffit is a segmental curve of 113 ft. radius, having a rise of 3 ft. 11 in. and providing a minimum vertical clearance of 19 ft. over the top of the rail at the abutment. This gives ample clearance over the side tracks as well as the required 22 ft. over the inner tracks.

A thickness of 18 in. was selected at the crown, while a 4 ft. 3 in. depth was set at the knee of the frame, both at the top of the leg and over the springing of the arch barrel. By carrying the extrados level for a distance of 5 ft. on either side of the center line and then proceeding on a straight grade to the 4 ft. 3 in. depth above the springing and continuing this line to the beveled corner, a satisfactory extradosal line was obtained.

The selection of a 2 ft. 6 in. width of leg at the bottom or hinge resulted in an arch span of about 63 ft. center to center. Strictly speaking, with the condition of moment at the springing, the span could very readily have been figured as a clear span of 59 ft., but inasmuch as it was desired to avoid any controversy on the subject, the conservative center to center span length was assumed as the basis for figuring the stresses.

For the same reason the assumption of fixity of the legs at their bottoms was avoided, although there was no doubt of obtaining such a condition by embedding in the rock for an appreciable depth. The objection to considering the base of the leg fixed seems to rest on the same fear that prevented the use of continuity and restraint in concrete beams and slabs for many decades, even though reinforced concrete structures had for a long time been so constructed that actual continuity and restraint could not be avoided. Of course, a design based on hinged supports is on the side of safety.

The method of analysis followed for the arch was that used by A. G. Hayden, with a few modifications, so that checking by state and federal authorities could be accomplished simply by following the stress sheet. An analysis was made for each of the two main sections (two others are symmetrical with those analyzed) and of one end rib carrying one reaction of the beam that supports the triangular section of the roadway, together with the sidewalk which at this location is cantilevered from the beam. The other end of the beam is supported by the retaining wall.

An H-20 truck loading was plotted on each section to be analyzed, and the maximum condition of such loading was designed for. As between the lighter and heavier sections, the reinforcement was varied, but the concrete cross sections held uniform. The sections were made 31½ ft. long by dividing the length of the barrel into four equal parts after deducting two ribs of 5 ft. each for the ends. The joints between the sections are designed as complete expansion joints with copper flashing and bituminous filler for water-proofing; each section thus acts as an independent unit. The total length of the barrel was determined by the capacity of the beam carrying the triangular sections, the depth of which is limited by the vertical distance from the curb to the bottom of the beam which follows the configuration of the arch. This in turn is governed by the clearances required over the various tracks.

The barrel length as used in the plans could have been further shortened by widening the beam, by the use of compressive reinforcement or by considering end restraint. Another possible alternative would be to modify the balustrade section so that it would be effective as a facia beam, giving a greater available girder depth. This, however, is accompanied with an increased span length and a heavier rib concentration. It would also necessitate the use of a double slab, one for the main carrying slab at the roadway level and above it a sidewalk slab for that section.

Additional reinforcement was provided in each arch section for protection against "edge slab" action at the request of the federal government engineers who felt that such action would take place even though the structure is an arch with a heavy concrete section at the haunches. An analysis was made for these edges by locating a rear wheel of a truck 1 ft. 3 in. from the edge in each lane and assuming a distribution through the pavement fill and slab at an angle of 45 deg. This gave a 3 ft. width of strip for an 18 in. depth which is the minimum (at the crown). Due to the skew crossing of the roadway, the location of these concentrations varied at the junction of the different sections, requiring analysis for each. By the use of influence tables for the arch sections the moments were figured and the additional reinforcement provided.

The triangular section of slab is designed as a one-way slab with reinforcement parallel to the arch axis. The sidewalk slab, designed as a cantilever, has the reinforcement normal to the beam that supports it. The balustrades are of two heights, those over the tracks being 6 ft. for protection against electric current in the event of future electrification, and the remainder being a normal 3½ ft.

All in all, the writer feels that this design points the way to an economic solution for conditions requiring a long skew span.

Cost of Cities' Sanitation Service

Surveys covering 94 cities of over 100,000 population show an average annual sanitation expenditure of $2.44 per person

A STUDY of sanitation service costs in the 94 cities of the United States having a population over 100,000, recently completed by the Bureau of the Census, Department of Commerce, shows a marked variation in the per capita cost in the individual cities, ranging from $0.29 to $6.44, for the year 1934. The compilation, which also included data for 1926, reveals that the average cost per person for the larger cities is greater than that for the smaller ones.

Cities in Group I (500,000 and over) spent an average of $2.92 per person for sanitary services in 1934. Those in Group II (300,000-500,000) averaged $2.08, and the smaller cities, shown in Group III (100,000 to 300,000), had the lowest figure, $1.63. The general average per capita cost was $2.44 compared with an expenditure of $3.19 in 1926—a decrease of about 23.5 per cent.

Items included

Among the expenses of sanitation service are payments for the operation and maintenance of sewers, sewage purification and disposal, street cleaning, collection and disposal of household and trade wastes, smoke inspection, public comfort stations, and inspection incident to the enforcement of sanitary regulations.

The 94 cities together spent $91,821,428 on sanitation, divided as follows: sewerage and sewage disposal $14,452,419; street cleaning $30,326,919; refuse collection and disposal $42,837,805; and for other sanitation $4,202,285.

These statistics cover the government of the city corporation proper and also independent districts practically coextensive with the cities. They also include a percentage of the financial transactions of the county government for certain cities having over 300,000 population, in order that data for such cities may be comparable with those of other cities in this class in which the ordinary county functions are performed by the city government. Classification of expenditures is based on functional activities and not on funds or budgetary appropriations.

The accompanying tabulation gives the detailed data for all the cities surveyed.

PER CAPITA COSTS FOR SANITATION SERVICE IN 1926 AND 1934

City	Sewers and Sewage Disposal		Street Cleaning		Refuse Collection and Disposal		Other Sanitation		Total	
	1934	1926	1934	1926	1934	1926	1934	1926	1934	1926
General Average	$.38	$.53	$.81	$1.49	$1.14	$1.04	$.11	$.13	$2.44	$3.19
Group I — Cities of 500,000 and over	.40	.61	1.06	2.07	1.35	1.03	.11	.13	2.92	3.84
New York, N. Y.	.31	.40	1.75	4.01*	2.04		.08	.06	4.18	4.47
Chicago, Ill.	.69	1.78	.68	.80	.84	1.52	.07	.10	2.28	4.20
Philadelphia, Pa.	.05	.20	1.06	1.60	.96	1.87	.09	.10	2.16	3.77
Detroit, Mich.	.33	.31	1.18	1.88	.71	1.05	.08	.13	2.30	3.37
Los Angeles, Calif.	.19	.19	.49	.70	.64	.85	.16	.16	1.48	1.90
Cleveland, Ohio	.28	.31	.20	1.46	1.10	1.18	.15	.30	1.73	3.25
St. Louis, Mo.	.26	.24	.43	.85	.29	.45	.14	.13	1.12	1.67
Baltimore, Md.	.41	.75	1.01	.77	1.28	1.26	.15	.16	2.85	2.94
Boston, Mass.	.79	1.08	.37	1.14	2.30	2.75	.20	.22	3.66	5.19
Pittsburgh, Pa.	.11	.13	.54	1.10	2.24	3.09	.29	.35	3.18	4.67
San Francisco, Calif.	.36	.48	.66	.98	.01	.01	.03	.03	1.06	1.50
Milwaukee, Wisc.	1.67	.57	.36	1.07	1.51	1.85	.19	.31	3.73	3.80
Buffalo, N. Y.	.15	.17	.63	.94	1.99	2.84	.22	.18	2.99	4.13
Washington, D. C.	.87	.76	1.08	1.07	1.36	1.89	.09	.13	3.40	3.85
Group II — Cities of 300,000 to 500,000	.39	.47	.54	.74	.99	1.26	.16	.17	2.08	2.64
Minneapolis, Minn.	.34	.24	.28	.56	.51	.67	.12	.17	1.25	1.64
New Orleans, La.	.80	1.14	.50	.51	1.03	1.13	.09	.05	2.42	2.83
Cincinnati, Ohio	.25	.25	.77	1.03	.78	.47	.11	.09	1.91	1.84
Newark, N. J.	.79	.80	1.11	.99	1.32	2.51	.61	.49	3.83	4.79
Kansas City, Mo.	.01	.11	.61	.75	1.07	.65	.09	.07	1.78	1.58
Seattle, Wash.	.30	.47	.19	.44	.99	1.83	.13	.18	1.61	2.92
Indianapolis, Ind.	.44	.64	.38	.36	.70	.84	.07	.06	1.59	1.90
Rochester, N. Y.	.46	.38	.49	.93	2.61	3.89	.16	.15	3.72	5.35
Jersey City, N. J.	.15	.19	1.05	1.67	1.44	1.30	.25	.24	2.89	3.40
Houston, Tex.	.58	.91	.09	.23	.53	.90	.03	.05	1.23	2.09†
Louisville, Ky.	.19	.18	.32	.39	.84	.81	.05	.10	1.40	1.48
Portland, Oreg.	.20	.23	.66	.92	.12	.14	.15	.27	1.13	1.56†
Group III — Cities of 100,000 to 300,000	.35	.38	.42	.64	.77	.96	.09	.14	1.63	2.12
Columbus, Ohio	.28	.39	.27	.69	.71	.84	.06	.11	1.32	2.03
Toledo, Ohio	.38	.25	.47	.77	.57	.50	.02	.11	1.44	1.63
Oakland, Calif.	.29	.22	.53	.87	.05	.31	.06	.12	.93	1.52
Denver, Colo.	.11	.20	.98	1.19	.06	.10	.13	.21	1.28	1.70
Atlanta, Ga.	.30	.21	.53	.68	.86	.86	.06	.08	1.75	1.83
Dallas, Tex.	.33	.45	.20	.54	.69	1.03	.06	.08	1.28	2.10
St. Paul, Minn.	.19	.29	.36	.49	.23	.27	....	.14	.78	1.19
Birmingham, Ala.	.06	.20	.15	.22	.52	.66	.04	.17	.77	1.25
Akron, Ohio	.26	.24	.24	.79	.30	.66	.01	.02	.81	1.71
Memphis, Tenn.	.18	.58	.23	.46	.68	1.16	.10	.18	1.19	2.38
Providence, R. I.	1.28	1.11	.36	.68	.77	.38	.26	.18	2.67	2.35
San Antonio, Tex.	.34	.12	.30	.52	.42	1.05	.04	.17	1.10	1.86
Omaha, Neb.	.15	.11	.16	.22	.34	.45	.09	.15	.74	.93
Syracuse, N. Y.	.46	.23	1.18	1.32	1.73	1.83	.07	.06	3.44	3.44
Dayton, Ohio	.98	.26	.19	.31	.53	1.22	.06	.13	1.76	1.92
Oklahoma City, Okla.	.23	.24	.36	.40	.40	.43	.05	.07	1.04	1.14
Worcester, Mass.	.87	.79	.45	.73	.68	1.05	.09	.10	2.09	2.67
Richmond, Va.	.24	.20	.30	.54	1.16	1.16	.11	.18	1.81	2.08
Youngstown, Ohio	.16	.12	.24	.14	.51	.70	.12	.08	1.03	1.04
Grand Rapids, Mich.	.36	.58	.16	.60	.30	.50	.02	.02	.84	1.70
Fort Worth, Tex.	.33	.30	.30	.40	.61	.71	.06	.04	1.30	1.45
Hartford, Conn.	.19	.22	.83	1.05	1.36	1.97	.25	.29	2.63	3.53
Flint, Mich.	.08	.38	.08	.26	.65	1.48	.01	.04	.82	2.16
New Haven, Conn.	.38	.20	.62	.77	.41	.61	.18	.17	1.59	1.75
San Diego, Calif.	.20	.40	.28	.30	.80	1.49	.06	.05	1.34	2.24
Long Beach, Calif.	.26	.76	.36	.49	1.11	1.60	.21	.48	1.94	3.33
Nashville, Tenn.	.03	.02	.37	.50	.68	.72	.28	.12	1.36	1.36
Springfield, Mass.	.16	.65	.89	.93	2.47	2.05	.20	.22	3.72	3.85
Tulsa, Okla.	.20	.34	.32	.40	.26	.50	.03	.13	.81	1.37
Bridgeport, Conn.	.46	.43	.35	.74	1.84	1.41	.08	.08	2.73	2.66
Des Moines, Iowa	.40	.88	.44	.68	.44	.71	.12	.23	1.40	2.50
Scranton, Pa.	.24	.39	.38	.36	1.16	1.52	.09	.08	1.87	2.35
Salt Lake City, Utah	....	.19	.12	.36	.24	.41	.09	.11	.45	1.07
Yonkers, N. Y.	.39	.23	1.18	.70	4.44	3.48	.43	.42	6.44	4.83
Paterson, N. J.	1.21	1.45	.34	.44	1.24	1.33	.08	.14	2.87	3.36
Jacksonville, Fla.	.84	1.05	.47	1.65	1.08	.30	.28	.31	2.67	3.31
Albany, N. Y.	.76	.67	2.71	2.22	.59	.26	.40	.50	4.46	3.65
Norfolk, Va.	.45	.55	.42	.97	1.04	1.06	.11	.14	2.02	2.72
Trenton, N. J.	.69	.34	.73	.74	.80	1.27	.14	.25	2.36	2.60
Chattanooga, Tenn.	.13	.16	.18	.29	.41	.70	.05	.18	.77	1.33
Kansas City, Kans.	.02	.10	.06	.25	.21	.45	....	.09	.29	.89
Fort Wayne, Ind.	.22	.22	.30	.52	.56	.43	.09	.10	1.17	1.27
Camden, N. J.	.36	.22	.29	.85	.63	.81	.01	.05	1.29	1.93
Erie, Pa.	.29	.26	.57	.35	.69	.69	....	.02	1.55	1.32
Elizabeth, N. J.	.29	.35	.81	1.21	.50	.74	.06	.05	1.66	2.35
Wichita, Kans.	.28	.16	.23	.39	.35	.50	.07	.12	.93	1.17
Spokane, Wash.	.21	.23	.40	.68	.46	.77	.09	.10	1.16	1.78
Fall River, Mass.	.12	.31	.06	.42	.48	1.10	.06	.07	.72	1.90
Cambridge, Mass.	.72	.90	1.15	.91	2.59	2.80	.10	.09	4.56	4.70
New Bedford, Mass.	.36	.78	.21	.66	1.27	1.75	.16	.19	2.00	3.38
Reading, Pa.	.42	.59	.38	.64	.43	.72	.11	.14	1.34	2.09
Knoxville, Tenn.	.11	.22	.21	.36	.47	.78	.06	.07	.85	1.43
Peoria, Ill.	.76	.16	.02	.53	.77	.71	.02	.03	1.57	1.43
South Bend, Ind.	.02	.12	.14	.46	.40	.37	.01	.01	.57	.96
Tacoma, Wash.	.26	.24	.27	.55*	.94	—A—	.05	.13	1.52	.92
Miami, Fla.	.48	1.14	.29	1.10	1.06	3.76	.22	.29	2.05	6.29
Gary, Ind.	.25	.21	.27	.74	.29	.21	....	....	.81	1.16
Canton, Ohio	.33	.47	.14	.15	.37	.54	.02	.04	.86	1.20
Wilmington, Del.	.16	.17	.49	.71	1.56	1.59	.08	.08	2.29	2.55
Tampa, Fla.	.23	.39	.51	.46	1.61	2.56	.10	.29	2.45	3.70
Somerville, Mass.	.65	.69	.27	.25	2.01	2.03	.01	....	2.94	2.97
El Paso, Tex.	.19	.27	.10	.55	.34	.74	.03	.12	.66	1.68
Evansville, Ind.	.13	.12	.24	.39	.26	.38	.02	.03	.65	.92
Lynn, Mass.	.77	.43	.14	.29	1.57	1.68	.11	.07	2.59	2.47
Utica, N. Y.	.08	.13	.63	1.15	1.40	1.62	.10	.13	2.21	3.03
Duluth, Minn.	.28	.37	.09	.35	.09	.14	.09	.17	.55	1.03
Waterbury, Conn.	1.14	.32	.32	.88	.42	.47	.07	.11	2.15	1.78
Lowell, Mass.	.35	.24	.34	.52	1.18	1.59	.12	.12	1.99	2.47

* Includes refuse collection and disposal.
—A— Included with street cleaning.
† Percentage of county transactions not included.

St. Louis Grinds Its Garbage

Hog-feeding disposal method abandoned in favor of municipal-operated central grinding stations where garbage is macerated in hammer-mills and flushed into sewers which empty into the Mississippi River.

THE DISPOSAL of garbage by grinding and discharging it into sewers has been tried as a temporary measure by several American cities within the past few years but St. Louis is the first municipality to adopt this scheme on a permanent basis. Since Feb. 19, 1935, practically all of the garbage collected in this city of 822,000 population has been handled in a central grinding plant located over a trunk sewer that empties into the Mississippi River. A second grinding plant was placed into operation on Dec. 15, 1936, and together these two plants will provide adequate and reserve garbage disposal facilities for a number of years to come.

Each plant with its grinding and conveyor equipment cost about $40,000, and operating costs at plant No. 1 have averaged slightly more than 40c. per ton of garbage. The original plant, equipped with two hammer-mill grinding units whose total rated capacity is 30 tons per hr., has taken care of peak summer loads as high as 460 tons per day without difficulty.

Previous to adoption of the grinding and sewer disposal system, St. Louis collected garbage in mule-team wagons and hauled it to the river front. Private contractors then barged this material to hog-farms at various points along the river, for which service the city paid from 34.5c. to $2.10 per ton. An incinerator plant was built in 1923 but it was soon abandoned.

In 1930 a five-year disposal contract was let to a contractor who supplied hog-farms on the Illinois side of the Mississippi River a few miles south of St. Louis, near the village of Monsanto. Directly opposite, on the Missouri shore, was located a high-class residential district, the inhabitants of which objected strenuously to the odor nuisance emanating from the garbage and hogs across the river. Finally, after two years of verbal objection, these people secured a restraining order from the circuit court. This was ignored by the city, however, and it was not until the winter of 1934, shortly after a new administration took office in St. Louis, that the department of streets and sewers was notified by the city counselor that unless some method of garbage disposal other than hog-feeding were adopted the city would be cited for contempt of court. The need for immediate action was further accentuated by the fact that the contract for barging away the garbage expired on Feb. 19, 1935.

Engineering studies were then initiated on three methods of disposal involving: (1) incineration; (2) conversion to animal feed; and (3) conversion to fertilizer. Cost estimates later revealed that plants of these types, providing adequate capacity, ranged from $600,000 to $3,000,000 and operating expenses varied from 50c. to $2.00 per ton. It was virtually impos-

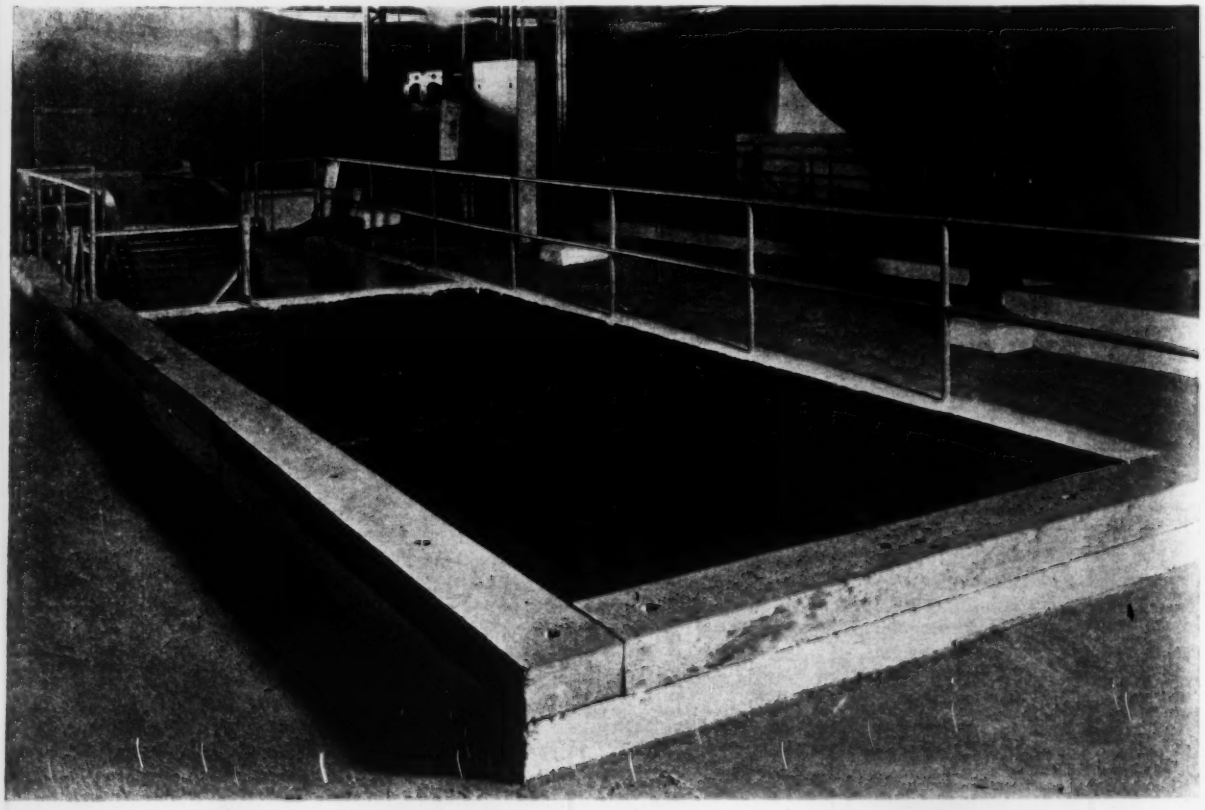


FIG. 1—GARBAGE GRINDING PLANT No. 1 showing the compact straight line arrangement of the receiving hopper, conveyor, and grinder. The 20-ton unit is in the foreground and the 10-ton unit is on the right.

sible to obtain sufficient appropriations for any of these installations and furthermore, their construction would have required from 12 to 18 months, which would have been far beyond the expiration time of the hog-farm barging contract.

Grinding scheme tested

The next approach to the problem was an investigation of the possibilities of grinding garbage and discharging it into sewers. Accordingly, in the summer of 1934 a 10-ton per hr. hammer-mill type grinder was set up, and after several months' trial this scheme was accepted as feasible.

Since the ground garbage was added to the sewage flow, which in turn discharged untreated into the Mississippi River, it was deemed advisable to obtain federal approval before this method was officially adopted. Under the Rivers and Harbors Act of 1889 the deposition in waterways of refuse other than that in liquid form is forbidden; a ruling was therefore sought approving the discharge of sewage containing finely ground garbage solids. Following tests witnessed by the corps of engineers, U. S. Army, the War Department sanctioned this practice for St. Louis.

Construction was then started immediately with city forces on a 30-ton per hr. central grinding plant located on city-owned property in the geographical center of the city, and this plant was completed and ready for operation when the hog-farm contract expired. The cost, not including land, engineering and overhead or contractor's profit, was about $40,000; maintenance costs to date have been negligible. To reduce collection costs and also provide reserve facilities in case of a major breakdown a second plant with a capacity of 40-tons per hr. has just been placed in operation at another point in the city. (Fig. 4.) This plant is practically a duplicate of the first installation, and it was built at a cost of about $40,000.

Operation of plant

Grinding Plant No. 1 comprises two hammer-mill grinders, with capacities of 10- and 20-ton per hr. respectively, fed by individual steel leak proof pan conveyors of special design which lead from the bottom of separate concrete hoppers. (Fig. 1.) The top of the hoppers are at floor level, for direct dumping from trucks.

The conveyor in passing under the hopper picks up garbage at a rate regulated by a vertical gate, and the conveyor then moves upward and forward at an angle of about 30 deg. Just before discharging into the grinder hopper the conveyor moves along horizontally for a short distance and thus provides opportunity for hand pickers to remove all

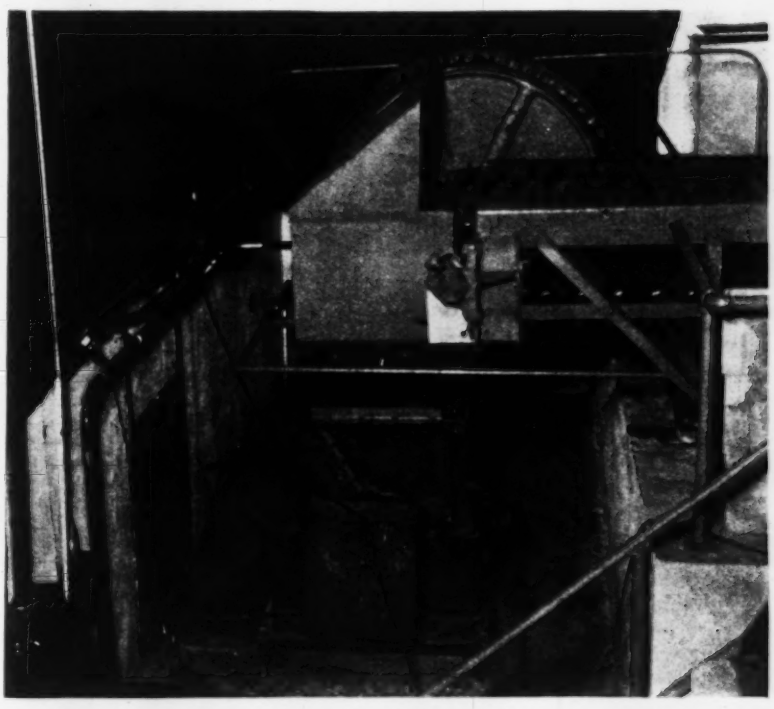
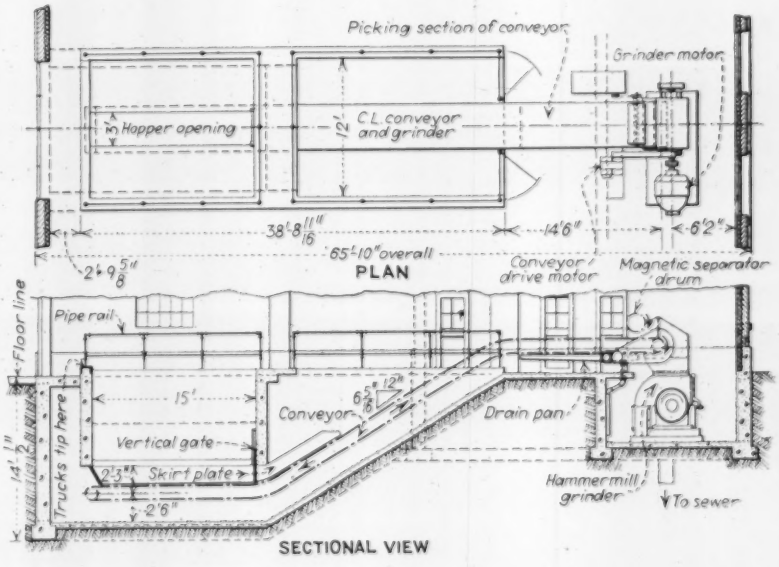
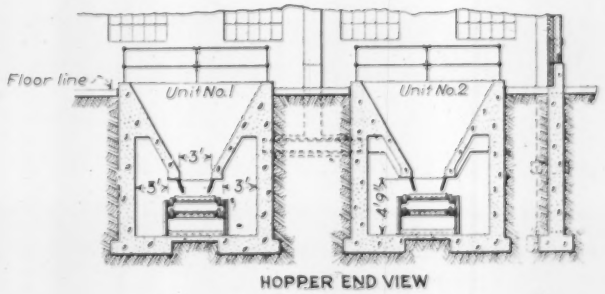


FIG. 2—HAMMER-MILL TYPE GRINDER with a rated capacity of 10-tons per hr. The garbage discharged by the conveyor into the hooded hopper above the grinder is sprayed with water at the rate of 400 g.p.m.

FIG. 3—DESIGN DETAILS of central grinding plant No. 2 where two 20-ton hammer-mill units have been installed. Plant No. 1 is identical in layout but the grinders are of 20- and 10-ton capacity respectively, and magnetic separators are not used.





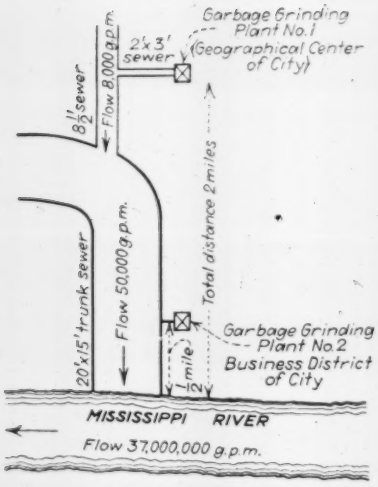


FIG. 4—CENTRAL GRINDING STATIO... were carefully located with relation to sewers into which the pulped garbage is discharged.

tin cars and other metallic materials. In the newer grinding plant No. 2 magnetic separators perform this function.

The garbage entering the grinder has a moisture content of 80 to 85 per cent, but while it is being pulped additional water at the rate of 400 g.p.m. is sprayed into the machine. The material discharged resembles thick soup in appearance; its solids content is 3 to 5 per cent, and the largest particles are ⅛ in.

The pulped material is discharged from the grinders into a 2x3 ft. brick sewer which, within a short distance, connects with an 8.5 ft. diam. sewer that has a normal dry weather flow of 8,000 g.p.m. (about 11.5 m.g.d.). After flowing several blocks this sewer merges with a 20x15 ft. trunk line in which the dry-weather flow is 50,000 g.p.m. (72 m.g.d.). The river outlet is reached after two miles of travel and here dilution takes place in the Mississippi when there is an average flow of 37,000,000 g.p.m. (53,280 m.g.d.).

It is stated that the ground garbage loses its identity in the sewage flow in about ¼ mi. of travel, and at the river outlet there are no discernible signs of the garbage additions. At no time has there been any deposition of solids in the sewers.

Pollutional effect on river

In discussing the pollutional effect of the garbage on the river, Frank J. McDevitt, director of the department of streets and sewers, said: "The U. S. Bureau of Fisheries made some tests on the biochemical-oxygen-demand value of St. Louis ground garbage and also on the dissolved oxygen content of the Mississippi River at various points in the vicinity of and below the city sewer outlets. The report on these tests indicated that the worst condition as regards the reduction of dissolved oxygen was near the sewer outlets, where the situation was described as adverse to critical, concerning sustenance of aquatic life. The fish in the Mississippi River adjacent to St. Louis, however, are mostly of the scavenger type such as gars, carp and channel cat, and they are usually found in greatest numbers around the sewer outlets."

Operating costs of the central grinder during the one year period from April 1935 to April 1936, in which time 40,792 tons of garbage were handled, averaged 41.3c. per ton. This figure includes maintenance, electric power, water and labor costs but does not include fixed charges. Power requirements averaged 4 kw. per ton and water consumption was about 1,000 gal. per ton. The operating personnel totals four men as compared with eight men formerly employed for loading and trimming barges.

Collection methods

In St. Louis garbage only is collected by the city, and this service is given three times a week. Other refuse is collected privately by contractors who charge individual householders an average of $5 a year.

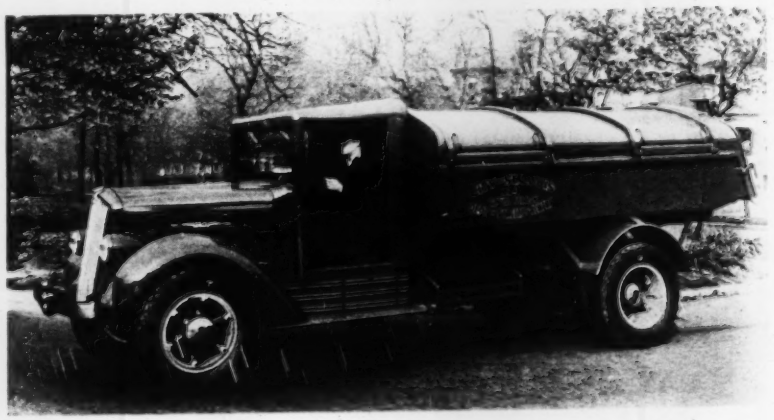
For many years private collectors were permitted to collect garbage upon payment of a fee of $20. When the prices for hogs and grain increased garbage became highly desirable for hog-feeding, and there was a tremendous increase in the number of private and unlicensed collectors operating within the city. They overlapped and duplicated the service rendered by the city and their methods of collection caused many complaints from citizens who objected to careless handling of receptacles and the dropping of garbage on thoroughfares.

Consequently a municipal ordinance was passed last June which increased the license fee to $200 a year and provided that licensed collectors be assigned to definite routes over which the city had supervisory powers. In addition, provision was made for the retail sale of garbage at the central grinding station at $1.00 a ton. This ordinance became effective in November and since that time the daily sales have averaged 75 tons. Collectors supplying hog farms have found it cheaper under this arrangement to buy garbage at the station than to collect it themselves; the city benefits not only in financial return but also in that it has less garbage to be ground and besides, collection service is under better control. When the hog-fattening season approaches the retail garbage sales will show a marked increase.

There is a definite correlation between hog and grain prices and the demand for garbage. In 1934 the average daily garbage collections amounted to 125 tons in winter and 460 tons in the summer; in 1935, a period of higher prices for hogs and corn, the average daily collections were 75 tons in the winter and 360 tons in the summer months. These figures are based on city service only and do not include private collections. The effect of private collections coincident with increasing prices for hogs and corn during the last three years is strikingly shown by the decreasing yearly tonnage figures of city-collected garbage: In 1933-34 the total was 56,614 tons; in 1934-35, 45,117 tons; and in 1935-36 only 40,792 tons.

To provide 3-day a week collection service the city maintains a fleet of 45 enclosed-body motor vehicles. Mule-drawn steel-lined wagons were formerly used but these have been gradually replaced and the last team was retired on Nov. 15, 1936. The motor truck bodies, 30 of which carry 8-ton loads, and 15 of 5-ton capacity, are of a special design developed by the department engineers. They are rear-dump models,

FIG. 5—COLLECTION SERVICE has been improved with the use of enclosed-type bodies designed by the city. When partly full the body is tilted up at a sharp angle to compact the load in the rear and this makes it possible to use all available storage capacity.



totally enclosed and provided with three sliding cover openings, as shown in Fig. 5. When the body becomes partly filled it is tilted up at a sharp angle in order to compact the garbage at the rear and thus provide additional storage space at the front end. In this way it is possible to completely utilize all available storage capacity without danger of spillage. The 8-ton trucks carry a crew of three men—a driver ($130 a month), a helper ($115) and a laborer ($3.50 a day). The smaller trucks have a crew of only two men. Collection costs per capita for the last three years have been as follows: 1933-34, $3.395; 1934-35, $4.644 and 1935-36, $4.887.

Acknowledgment

This article was prepared from information furnished by Frank J. McDevitt, director of the St. Louis department of streets and sewers, under whose direction the grinding plants were designed and who is in charge of their operation and the garbage collection service.

Scour Prevention Below Bonneville Dam

Model Studies result in modification of the original design for the spillway of the dam—Final design altered from theoretically correct design because expected changes in tailwater level.

By J. C. Stevens
Consulting Engineer, Portland, Ore.

AN EXHAUSTIVE STUDY has been made by means of hydraulic models to determine a type of baffle that will most effectively prevent scour of the riverbed below Bonneville dam.

The spillway dam in the main channel of Columbia river consists essentially of an overflow section 1,070 ft. long which is divided by seventeen 10-ft. piers into eighteen 50-ft. bays in twelve of which are to be placed steel gates 50 ft. high, and in six (three at each end) similar gates 60 ft. high.

In operation, the headwater will be controlled to a normal operating level between El. 72.0 and 82.5, depending on the discharge. With all gates open the maximum recorded discharge (1894) of 1,170,000 sec.-ft. can pass the spillway with headwater at El. 75.5 while a flood of nearly 2,000,000 sec.-ft. could probably pass the spillway without overtopping the roadway.

The foundation for the dam is a consolidated agglomerate of volcanic tuff, known locally as the Eagle Creek formation, and the dam rests on what appears to be a dome of this bed rock, since the rock slopes gently away from the dam in all directions. The river bed is very rough and is strewn with large boulders, some having a volume upward of 500 cu. yd.

Bedrock is exposed in the center of the channel but is buried along each shore underneath 30 to 60 ft. of river debris. Fig. 4 shows the result of a mechanical analysis of an 8-ton sample of bed material in which everything over 30 in. mean diameter was discarded. The rock profile along the toe of the dam is shown in Fig. 2, and Fig. 3 is a typical cross-section showing the type of baffle finally adopted.

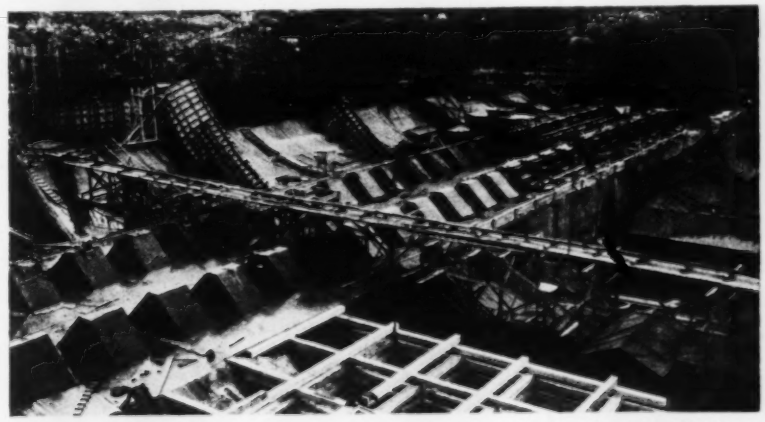


FIG. 1—BAFFLES on the spillway deck at Bonneville Dam. The deck level is the same across the channel but the apron (on which the small buildings at the right stand) is at varying levels depending on the rock level.

Model Studies

In order to develop a design that would be most effective in preventing scour of the riverbed below the structure, model studies were begun at the Bonneville Hydraulic Laboratory in the spring of 1934 (See *ENR* Aug. 8, 1935, p.195). A 1:36 model of three of the gates, piers, spillway, apron and riverbed representing a width of 180 ft. of the prototype, was built in the spillway flume which is 5 ft. in width and has glass sides for observing the behavior of the water on the bed. The bed material of the model is a fine gravel artificially mixed from ¼ to 1-in. mean diameter, and within that range follows very closely the curve of Fig. 4.

Some 140 experiments were made on as many combinations of deck, apron, baffle, etc., to determine scour, before the final profile and type of baffle shown in Fig. 3 were decided upon. The adopted baffle consists of wedge-shaped blocks 6 ft. wide, 6 ft. high with 1:1 sloping faces both upstream and down stream. The blocks are in two transverse rows with 6-ft. spaces between the blocks in each row and 30 ft. between rows. Blocks in one row are opposite spaces in the other row.

As far as the writer is aware this particular baffle block has not heretofore been used. It was adopted for three important reasons: (1) its use resulted in less movement of bed material than for any other form tried, (2) it is simple to construct, and (3) it is easily maintained.

Deck Elevation

Elevation of the deck is a most important factor in preventing scour. As the water reaches the deck it is flowing at super-critical velocity and a hydraulic jump must inevitably occur downstream (except when the dam is submerged more than 67 per cent, theoretically). If it were possible to construct a dam so that the normal tailwater level coincided with the higher conjugate depth of the hydraulic jump for all discharges, much would be accomplished toward scour prevention. This, however, is seldom possible. The higher conjugate depth is governed entirely by the velocity and depth just prior to the jump, while the tailwater level is governed by river channel below the dam. The two functions usually have only one point in common. (See *Proceedings*, Am. Soc. C. E., February 1935, p. 145 and August, 1935, p. 906; also *ENR*, March 14, 1935, p. 373.)

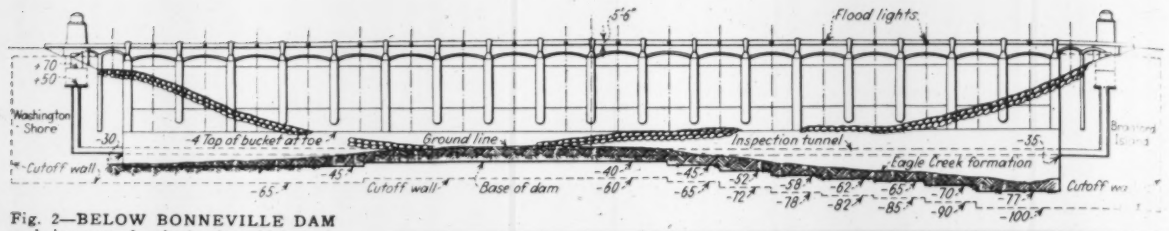


Fig. 2—BELOW BONNEVILLE DAM rock is exposed only in the midchannel. At the sides it is covered with varying depths of river debris made up in part of large boulders.

SCHEDULE OF GATE OPENINGS IN TERMS OF THE PROTOTYPE

River discharge sec. ft.	Tailwater ft.	Headwater ft.	Number of gates open	Discharge per gate sec.-ft.
300,000	30.2	75.0	8	37,500
400,000	35.4	77.0	8	50,000
500,000	40.1	79.2	10	50,000
600,000	44.3	81.3	12	50,000
800,000	51.8	82.5	15	53,300
1,000,000	58.2	82.5	18	55,500
1,170,000	63.4	75.5	18	65,000
1,340,000	69.0	79.8	18	74,500

The higher conjugate depth of the jump can be controlled to a great extent by fixing the deck or apron on which the jump occurs at the proper elevation. Fig. 5 shows the relation between the tailwater level and the higher conjugate depths of the jump for the Bonneville dam. If the deck were raised to El. —8 it appears that a very excellent correspondence could be obtained for all discharges less than 800,000 sec.-ft.

In spite of this, however, a deck elevation of —16 was adopted for the following reasons:

a) There will be some retrogression of the riverbed below the dam accompanied by a lowering of the tailwater due to partial stopping of the bed load movement past the dam.

b) The tailwater may also be lowered by projected channel improvements below the dam for navigation by seagoing vessels.

c) Full opening of one or more gates on a low river, through error, or to pass drift, or for any emergency, must be expected occasionally. Less damage to the riverbed will result at such times if the deck is low enough to have a substantial depth of water on it.

d) Baffle blocks substantially submerged, are not so likely to be injured by the impact of large logs going over the crest of the dam.

e) Economy in construction. A deck at El. —8 would cost some $250,000 more than one at El. —16.

It appeared best, therefore, to sacrifice some hydraulic efficiency in favor of practical considerations and adopt a deck level considerably lower than model experiments indicated as ideal.

In making tests to determine the best type of baffle, it was necessary to adopt a schedule of gate openings. The elevation of tailwater depends solely on the discharge in the river, while the concentration of discharge on the deck depends on the number of gates opened to pass that discharge. The schedule given above was generally followed in the tests.

Results of the tests

The efficacy of any combination of baffle and deck elevation is best shown by the amount of scour produced, and if the experiments are run for the same length of time with the same initial bed conditions, the relative values of these combinations are well established. It was found by experience that a flow of 400,000 sec.-ft. through eight gates is a fair index of the value of any particular combination, as it represents the largest discharge per gate with the lowest tailwater. A few typical results of the tests are given in Figs. 6 to 11, from which the following conclusions may be drawn: Each experiment was continued for at least one hour in the model, equivalent to six hours in nature, and all illustrated except Fig. 11 was for 400,000 sec.-ft. through eight gates and are therefore strictly comparable.

A sloping deck without baffles (Fig. 6) gave a maximum of scour and was found to be entirely impracticable for this structure. The *theory* of the sloping deck is that the correct tailwater level corresponding to the higher conjugate depth of the hydraulic jump will be encountered automatically by the jump and the energy absorbed by it. As far as evidenced by scour, these tests did not substantiate that expectation.

A deck without baffles at El. —16 (Fig. 7) shows that some form of baffle is necessary on the deck, in order to insure the jump occurring on the deck and to aid in destruction of the energy of overflow.

A flat deck with the type of baffle finally adopted, the deck being at El. —16 (Fig. 8) was found most effective in preventing scour for the conditions at Bonneville Dam.

The same baffles on a deck at El. —25 (Fig. 9) greatly increased the scour over that shown in Fig. 8.

The same baffles on a deck at El. —12 (Fig. 10) produced less scour than with the deck at El. —25. Note how the velocities become practically zero at stream bed.

Fig. 11 shows the same deck as in Fig. 10 but with the highest discharge that the laboratory was capable of delivering.

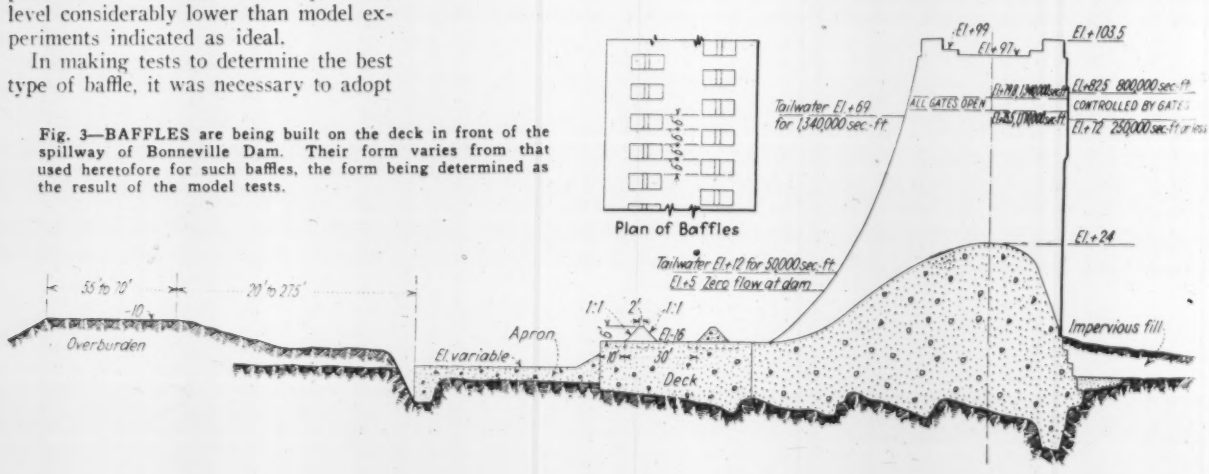


Fig. 3—BAFFLES are being built on the deck in front of the spillway of Bonneville Dam. Their form varies from that used heretofore for such baffles, the form being determined as the result of the model tests.

corresponding to a flow of 1,340,000 sec.-ft. No hydraulic jump occurred because the submergence of the crest, 81.5 per cent. The total fall was only 10.5 ft. Note also that velocities are no longer negligible near the bed. Such a flood would cause scour if there were no dam.

Maintenance of baffles

Aside from the excellent hydraulic behavior of this type of baffle, another and very important consideration is the ease with which it can be maintained. A caisson has been designed that can be floated in place and sunk over three of the blocks in one row. It seals on the deck and after being pumped out exposes the baffles enclosed for examination and repair. This can be done progressively across the apron at any low water season, after cutting off the flow opposite the caisson by closing the proper gates.

The effectiveness of this type of baffle is attributed to the multiplicity of cross-currents and eddies produced in the prism of the water all of which are deflected upward leaving only the slow moving ground eddy in contact with the bed. The integrated velocities as registered by the current meter over a definite period of time are zero near the bed (Fig. 10). The bed material is not moved by the integrated velocities given by a current meter. It is the "stray currents" that strike the bed with the force and somewhat after the fashion of a whip lash that moves this material.

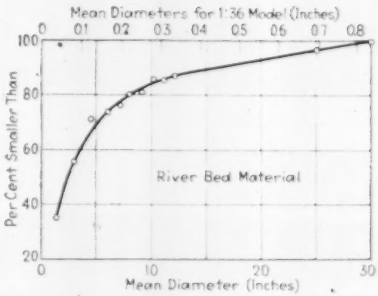
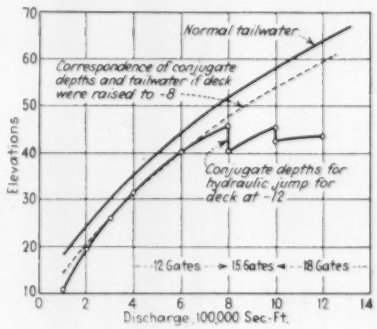


Fig. 4—ANALYSIS of the riverbed material shows that there is a wide range of materials even after everything with a mean diameter of over 30 in. had been discarded.

Fig. 5—A DECK ELEVATION of −8 gave the best results in the model studies but a lower elevation was chosen for the dam due to economic and other considerations.


Normal tailwater
Correspondence of conjugate depths and tailwater if deck were raised to -8
Conjugate depths for hydraulic jump for deck at -12
Elevations
12 Gates
15 Gates
18 Gates
Discharge 100,000 Sec.-Ft.

Figs. 6-7—SERIOUS SCOUR developed in the channel below the model dam when a sloping deck and a deck at El. −16 without baffles were tested.

The water strikes the first row of baffles with a velocity of over 50 ft. per second. The portions of the flow prism striking the sloping face of these baffles are deflected upward through the otherwise horizontally flowing portions just over the baffles. The portions passing through the spaces in the first row are immediately deflected upward when they encounter the front faces of the second row of baffles. The eddy currents produced by this action together with the surface eddy and the hydraulic jump absorb most of the energy of overflow in the uppermost portions of the water prism.

Sloping back found advantageous

A decided difference was found in favor of sloping the back side of the baffle block rather than making it vertical. This can only be explained in the light of "stray currents." The lee side of the baffle blocks is believed to be a fruitful source of these "stray currents" by reason of the irregularly periodic collapse of the lower pressures existing there. (For low tailwater these low pressure zones may even become partial vacuums.) These low pressure zones are bounded by the baffle face and when they collapse this face takes the recoil, so to speak, the "stray currents" being shot out as from a cannon at right angles

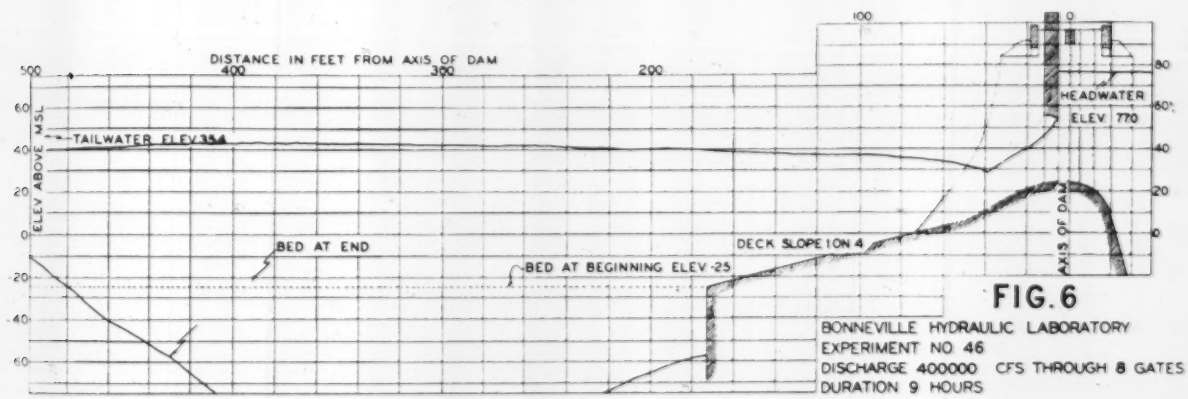

DISTANCE IN FEET FROM AXIS OF DAM
ELEV ABOVE MSL
TAILWATER ELEV 354
BED AT END
BED AT BEGINNING ELEV -25
DECK SLOPE 1 ON 4
HEADWATER ELEV 770
AXIS OF DAM

FIG. 6

BONNEVILLE HYDRAULIC LABORATORY
EXPERIMENT NO. 46
DISCHARGE 400000 CFS THROUGH 8 GATES
DURATION 9 HOURS

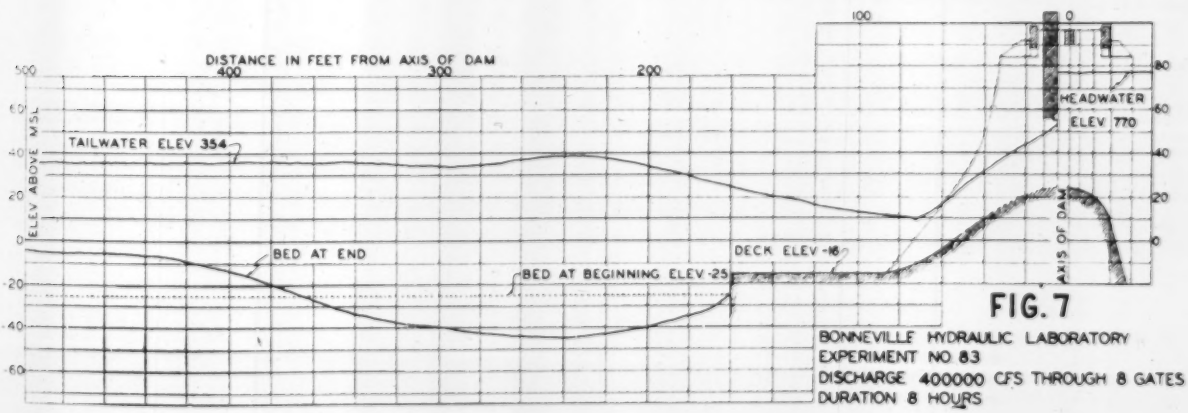


FIG. 7

BONNEVILLE HYDRAULIC LABORATORY
EXPERIMENT NO. 83
DISCHARGE 400000 CFS THROUGH 8 GATES
DURATION 8 HOURS

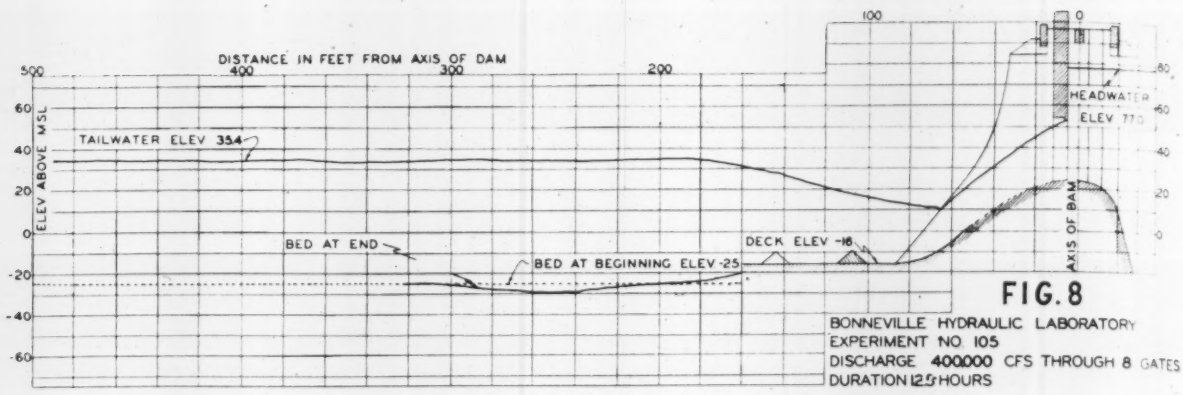


FIG. 8

BONNEVILLE HYDRAULIC LABORATORY
EXPERIMENT NO 105
DISCHARGE 400000 CFS THROUGH 8 GATES
DURATION 12½ HOURS

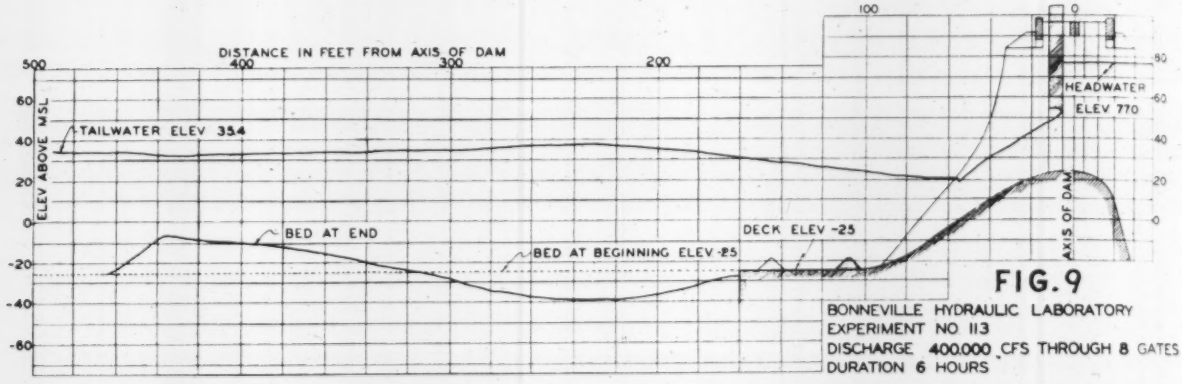


FIG. 9

BONNEVILLE HYDRAULIC LABORATORY
EXPERIMENT NO 113
DISCHARGE 400000 CFS THROUGH 8 GATES
DURATION 6 HOURS

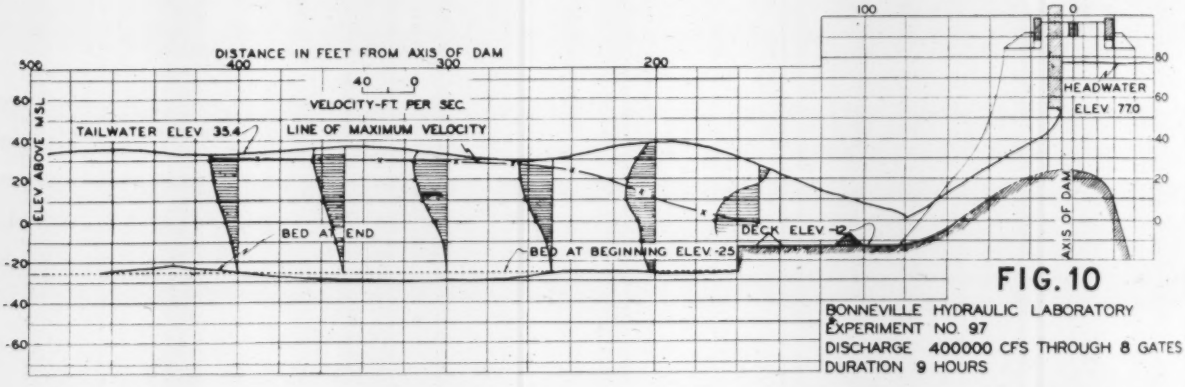


FIG. 10

BONNEVILLE HYDRAULIC LABORATORY
EXPERIMENT NO. 97
DISCHARGE 400000 CFS THROUGH 8 GATES
DURATION 9 HOURS

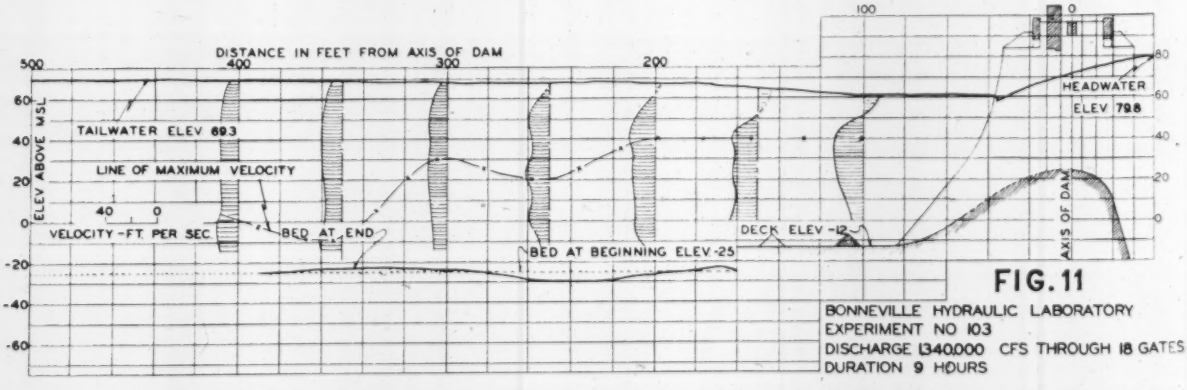


FIG. 11

BONNEVILLE HYDRAULIC LABORATORY
EXPERIMENT NO 103
DISCHARGE 1340000 CFS THROUGH 18 GATES
DURATION 9 HOURS

Fig. 8-11—A FLAT DECK with baffles of approved design was tested to determine the effect of change in deck elevation. The adopted elevation is shown in Fig. 8. Though not the best theoretically for present conditions this deck elevation gave very satisfactory results and it will continue to serve effectively if tailwater levels are reduced as is expected.

to the baffle face. If the baffle face is vertical these stray currents are shot horizontally, but if the face is sloping they are shot upward and hence do not contact the stream bed with destructive effect.

The Bonneville navigation and power project is being constructed by the U. S. Engineer Corps, Col. T. M. Robins, division engineer, Lieut. Col. C. F. Williams, district engineer, C. I. Grimm, head civilian engineer. The work in the Bonneville Hydraulic Laboratory is being done under the advisory supervision of the writer, with A. J. Gilardi, engineer, in direct charge.

Letters to the Editor

Joint Meetings on Soil Mechanics

Sir—At the present time considerable interest is manifest among civil engineers in the new field of soil mechanics, and a number of our national engineering societies are recognizing this interest by organizing committees or sections. Each has expressed a desire to cooperate with the others and I have been wondering how far this cooperation might go.

Multiplicity of Organizations

At the present time some phase of soil mechanics is being handled by the American Society of Civil Engineers (through the newly formed soil mechanics and foundation division); the American Society for Testing Materials (through the newly formed committee D-18 on soils for engineering purposes); the Highway Research Board (through the department of soils investigations); and the Society for the Promotion of Engineering Education (through the committee on foundation engineering and soil mechanics of the civil engineering sections).

Each of these groups holds an annual meeting, and the A.S.C.E. also quarterly meetings. It is obviously going to be difficult for very many to attend more than one of these meetings. Would it not be possible for all these groups to come together for a soil mechanics meeting, say every two years? In that way many men who are not able to attend even one meeting a year, might find it possible to attend this larger meeting. There is no question of the value of bringing together men from the various fields of activity in soil mechanics.

Literature Is Scattered

Practically every one who has attempted to self-educate himself in soil mechanics has found the written material more or less inaccessible. Articles written for any of the four organizations mentioned are published in the Proceedings of that society along with hundreds of other pages of articles. The size of the volumes of the various proceedings is becoming so large some engineers are finding it necessary to cut them up and discard the major portion. The engineer who moves about frequently will find it decidedly inconvenient to take around with him the complete volumes.

My second suggestion then is that these organizations consider the possibility of cooperating in the publication of their soil mechanics papers so that the person interested in that phase only can secure all the papers with greater ease and in a convenient form.

E. E. BAUER

Assistant Professor of Civil Engineering, University of Illinois.

Urbana, Ill.
Dec. 15, 1936

(Prof. Bauer's views are discussed below by Carlton S. Proctor, chairman of the new Soil Mechanics and Foundations Division of the American Society of Civil Engineers. —EDITOR)

Prof. Bauer is very evidently ignorant of the committee work now being done under the American Society of Civil Engineers' new division, particularly that under the chairmanship of William P. Creager in the compilation of a recommended bibliography and that under the chairmanship of Prof. William P. Kimball in the preparation of a glossary of terms and classification of soils.

It is planned that much of the work of the division, including that of the new committees on sampling and testing, seepage, and records of structural settlements, etc., may be available to the profession in the form of manuals, and when Prof. Bauer is more familiar with the work and program of the division I hope that he will prefer cooperation with its activities to the suggestion which he makes.

CARLTON S. PROCTOR

New York,
Dec. 22, 1936

Soil Erosion

Sir—Quite naturally I have read with interest the staff review and criticism of "Soil Erosion and Its Control" which appeared in your issue of Dec. 31, 1936. I am most grateful for your generous consideration. One or two points, however, seem to require further discussion in the interests of fairness and more complete understanding. I refer to the following statement taken from the review:

"Yet the engineering reader . . . wil be inclined to ask whether the elaborate designs and instructions for building thin reinforced-concrete dams will really enable the farmer to do work that is essentially of engineering character. The earth dams that are discussed also involve serious hazards."

On p. 255 of the book in question appears the statement: " . . . consequently when a structure of this type is contemplated it is recommended that an engineer experienced in this sort of work be called in to design the dam and supervise its construction. The material that follows is intended to acquaint the landowner with the problems involved and to be of assistance to engineers."

Dissolved Matter

Again, when calling attention to the U. S. Bureau of Chemistry and Soils' estimate that 270 million tons of dissolved matter (containing 63 million tons of plant food) go to the sea every year as a result of uncontrolled erosion, the reviewer says:

" . . . it does seem unlikely that water will ever be robbed of its dissolving power, or that the total amount of water going to the sea will be reduced. In fact, when (if ever) all water is made to sink into the ground before it reaches the rivers it will probably carry away even more dissolved matter than it does today."

Unfortunately, as pointed out repeatedly in the book, this is one of the numerous questions in connection with erosion that cannot as yet be answered in definite terms because of insufficient data. On the basis of a few analyses of the effluent from tile drains, however, it can be said that such water (which has percolated slowly through the ground) contains a relatively small amount of soluble plant nutrients. Apparently dissolving power depends to some extent on the placidity or turbulence of the dissolving medium, else there would be little reason to stir a cup of coffee.

QUINCY C. AYRES

Associate Professor, Iowa State College.

Ames, Iowa,
Jan. 6, 1937.

Professor Ayres' sound and constructive purpose in relation to dam designing was not meant to be questioned by the passage cited in the second paragraph of the above letter. The criticism, if any, was of the treatment which comprised detail section drawings, reinforcement layouts and related details and instructions for dam design, all clearly intended for direct use and not specially adapted "to acquaint the land owner with the problem involved." The cautionary statement on page 255, to which the above letter refers, might easily be overlooked. The design chapters might even mislead many engineers who lack experience in the design and construction of dams into believing that the book gives them a complete and sufficient basis for undertaking to build a dam. We are old-fashioned enough to believe that even relatively small dams are structures of sufficient difficulty and hazard to require thorough experience in design and construction, at the risk of creating a public danger. —EDITOR)

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Editorial offices at 330 West 42nd Street, New York

January 14, 1937

Works Department in Prospect

IF A LARGE CORPORATION should carry on a multiplicity of construction operations through scattered bureaus reporting only to the chief accountant and the board of directors, it would stand indicted as a flagrant example of bad organization. The federal government is subject to just this indictment, as its construction work is carried on by dozens of bureaus, departments and independent offices with no central direction whatever. Past agitation for reform failed, however. Now, at last, a presidential committee has outlined a plan for a public-works department that has excellent chances of adoption by Congress. Centralization of construction in a single department is so logical and has such overwhelming approval through public and private experience that the counter-arguments must be unusually strong if they are to prevail. The size and diversity of federal construction operations is not a valid reason against centralization. The problems of adjustment from the present condition, and they are many, appear quite possible of solution. Probably the most difficult question involved is that of retaining the morale and effectiveness of existing organizations of long tradition and well-established relations with their cooperating agencies. The details of organizing a central works department will therefore call for unusual forethought and judgment. Fundamentally, however, the plan promises such far-reaching improvement of government method as to command general support.

More in Detail

LAST WEEK we spoke of the bright prospect that lies before the construction industry. The facts are so interesting, however, as to warrant a further statement more in detail. Outstanding among current developments is the shift of responsibility for public-works financing from the federal government to the states and cities, where it belongs. In this movement there is hope of an early demise of relief labor philosophy and the return to practices of highest efficiency. Another hopeful sign is increased private investment—for new factories, new homes and new stores—and indications that utilities may soon begin new investment. Private work should therefore soon come into a normal relationship to public work. The vigorous activity in sewerage and waterworks construction means that the demand for these facilities is growing in a way that cannot be disregarded. Record-breaking bridge awards reflect expenditures for grade crossing elimination that are clearly destined to continue in a consistent campaign. Public building, aided by PWA housing and school construction, may in part be a non-recurring item, but it is the only element in the construction field that at the moment gives only qualified promise. Disquieting factors are rising prices of materials and labor, which may put a brake on advance, and the possibility of a return to shoddy building practices on the prospect of any sort of boom. Both these hazards deserve thought; but the prospect is that a 20 per cent increase in construction (compared with last year's 50 per cent) will make 1937 a seven billion dollar year.

Tunneling Activity

TUNNELING, always an exceptionally interesting phase of construction activities, will have unexpected prominence in the coming year's work. Opening of bids this week for the first shafts of New York's Delaware River water supply project marks the beginning of an 85-mile bore rarely equaled in tunnel history—among current projects only by the Colorado River Aqueduct. Shafts up to 1,600 ft. deep and the Hudson River crossing will make this project one of the most interesting ever driven. The East and Hudson River vehicle crossings will further increase tunneling activity in New York. Difficulties to be encountered in driving these tubes make them outstanding in their class. Looking westward, underground work looms large in Buffalo, Detroit and Chicago, as these cities are being honeycombed with sewer tunnels. And still farther west the diversion tunnels for several dams and continuation of the Colorado River project assure maintained activity in tunneling in a region that contributed most largely to the recent advance of the art.

Watch Labor Costs

CONTRACTORS AND ENGINEERS planning on construction work will do well to take note of the labor cost situation. Rising labor rates are helping establish new high levels of construction costs not seen for more than a decade. The phenomenal rise of last year has continued into this year with no indication of letup. Our reports for twenty cities now place the average common construction labor rate at more than sixty cents, the highest we have ever recorded. Likewise the average skilled rate has risen to $1.24, near the top level. The steady upturn in wages is difficult to understand, but it is apparently the result of new social trends rather than any acute worker shortage. Nationwide reports indicate that union agreements are being renewed at higher levels, and further study shows that non-union rates have reached organized scales in many communities. Regardless of the cause of increasing labor costs, it is important that all those contemplating construction work realize their significance.

Courageous Rejection

IT IS REFRESHING to hear that the Rockland-Westchester Hudson River Crossing Authority has reported to the New York legislature that the construction of a bridge or vehicle tunnel across the Hudson River between Tarrytown and Nyack, N. Y., is not justified economically. In that region the river is over two miles wide and an adequate foundation for bridge piers can be found only at great depth, the submerged gorge of the river extending far above that point. When a river crossing at Tarrytown was first proposed, it hardly seemed possible that it would be considered seriously, but the proponents persuaded the legislature to set up an authority to construct either a bridge or a tunnel if either was found to be practicable. In view of the fact that the legislature felt warranted in going that far the temptation must have been strong for the bridge authority to endorse the project, especially if federal funds were available on a loan-and-grant basis, for in the background

must have been the knowledge that once the project got under way the state would not drop it though the cost might exceed the original estimate. This temptation the board has resisted. It finds that even with a liberal grant from the federal government neither a bridge nor a tunnel could be made self-liquidating. Such frank rejection of what would have been an interesting construction problem helps to maintain confidence in the system under which the study was made.

Ingenuity in Modernization

ONE OF THE incidental evidences of a new age of road service and thinking is the current rebuilding of road crossings that only a few years ago seemed thoroughly up to date. Thus, only in 1909 the Lackawanna modernized its line in connection with extensive relocation improvements, and part of the work was a series of fine concrete bridges carrying main highways across the line; but, though up to the minute at the time, many of these crossings are obsolete today and constitute hazards that can no longer be tolerated. Out of this condition arises the interesting structural problem discussed by M. Hirschthal on another page. It presents an excellent example of how structural ingenuity and skill are called upon in providing for changed needs. The analysis of the case is worth study because it suggests how effective use may be made of old structures as part of a modernized layout.

Garbage Grinding on Trial

GRINDING GARBAGE and dumping it into sewers for water carriage disposal is receiving wide attention from municipal authorities. In one city, St. Louis, the method has been adopted for handling all garbage (see p. 58). The method is attractive because of its simplicity and, where treatment of sewage is not involved, its low cost. Unfortunately, proper appraisal of its merits and shortcomings cannot yet be made because the available data are meager; but its development and implications are of more than passing interest.

The idea of using sewers for the transportation of ground garbage originated in Lebanon, Pa., in 1923. After a short trial the practice was abandoned and nothing more was done until 1933, when Baltimore operated a grinding station for a short time to relieve an overloaded incinerator. Indianapolis installed a grinding unit at its sewage treatment works in 1935, when a reduction plant went out of service, and for seven months macerated garbage was treated with sewage. Durham, N. C., also added garbage to its sewage flow for a short time. But the first city to adopt grinding exclusively for the disposal of garbage was St. Louis. Here, in contrast to the operations at other places, the sewage flow with its additional load of garbage solids does not pass through a treatment plant but discharges directly into the Mississippi River.

This latter fact immediately raises the question of stream pollution. Garbage is organic matter, subject to putrefaction, and therefore every bit of garbage that enters a river adds pollutional load to a stream that perhaps is already overburdened. From this consideration alone the practice of grinding garbage for eventual river disposal condemns itself; it is contrary in principle and fact to the countrywide effort now being directed toward abatement of pollution in streams and rivers.

It is true that, within limits, a mixture of garbage and sewage can be purified successfully by a treatment plant, but nice questions of economics are involved. No disposal plant will furnish treatment for the additional load of the garbage solids without increase in operating cost. Few figures are available, but Baltimore experience indicates that operating cost would approach $3 per wet ton, and when grinding charges are included the total cost would be well above $3—and this includes no expense for necessary enlargement of the disposal plant. It would seem, then, that where cost is a factor several other methods of garbage disposal have prior claim to consideration.

Because of the short time that has elapsed since garbage grinding has been under investigation and trial, it is hardly opportune for municipalities to be seriously influenced toward its adoption. The evidence thus far is wholly inadequate for making a sound analysis of performance and cost.

Where Practice Remains Backward

CONSTRUCTION is exceptionally stubborn in clinging to crude practices in building earth fills. The advanced procedure in making fills for roads that was so excellently presented by two writers in last week's issue unfortunately is not yet customary practice. The usual earth fill, whether for road, railway or levee or a piece of backfill, is a mere dumped mass that rarely remains at the elevation or cross-section to which it was shaped. Subsidence or slip within a few years does not reflect praiseworthy earthwork engineering.

Though knowledge of soil mechanics was very limited in the past, advantage was not taken of the then available knowledge of soils and of the mechanical advantage of placing them in thin layers that could be solidified by common means of compaction. Even when experience in building earth dams furnished proof of the benefit of these practices they were neglected in other earthwork.

Practice has been equally blind to the possibilities of mechanical means for obtaining compaction. Puddling and jetting are haphazard in application. Rolling is nearly as irrational. It has taken a quarter of a century for the undoubted qualities of the sheepsfoot roller to be appreciated. No invention and scarcely any curiosity have been shown in the use and development of power tamping or in vibration.

Fill construction, except in earth dams, is a distinct backwash in the current of engineering progress. Highway engineering perhaps is taking more notice of this stagnation than are most other branches, but it still has much farther to go. Yet even now there are indications that it is leaning to dogmatic doctrine, a course not justified by the little that we now have learned of the science of soil behavior. It is too soon to clamp the knowledge of soils into a bundle of formulas.

And, as badly as certainty of stable levees and backfills is required, roadbuilding presents a greater demand for assured integrity of fill construction. The smooth and safe movement of a great and growing volume of transport depends on this integrity no less than on line and profile and on wide travel lanes. This is an objective that warrants more than the meager funds that road departments are now allotting to foundation study.

CURRENT NEWS

More Public Works In New Budget

Nearly $500,000,000 provided for public construction in fiscal year 1937-38 by President's budget

Increased expenditure for general public works is contemplated during the next fiscal year. In line with his policy that expenditures for general public works should be at a rate of $500,000,000 annually, the President approaches that amount in asking Congress for $451,108,963 for such expenditures during the next fiscal year. The total is made up as follows:

Tennessee Valley Authority	$49,000,000
Veterans' Administration	10,000,000
Department of Agriculture	152,900,000
Department of Commerce	1,000,000
Department of the Interior	58,052,000
Department of Justice	600,000
Department of State	4,250,000
Treasury Department	45,306,963
War Department	130,000,000
Total Public Works Program	$451,108,963

This total compares with $124,429,000 actually expended for general public works in the fiscal year ended June 30, 1936 and with an estimated total of $318,590,000.

Departmental increases

An increase of $15,000,000 appears in the amount asked for federal buildings to be constructed by the Treasury Department. War Department public works are increased by $45,00,000. The Department of Agriculture asks for an increase of $57,000,000 for its public works expenditures. Interior Department public works calls for an additional $13,000,000.

Expenditures for work relief program are to be estimated for in March, but the budget has been formulated with the idea that the amount needed for relief will not exceed $1,537,123,000. It is planned, however, to reduce loans and grants to states and municipalities to $183,000,000 which is about the balance remaining in the $300,000,000 fund earmarked by Congress at the last session. Loans and grants during the present fiscal year, however, are expected to total $236,000,000.

Highway program

Nothing in the budget changes the highway program. The President asks for appropriations totaling $181,500,000. If it should develop before Congress adjourns that additional appropriations will be necessary to cover the amounts authorized at the last session of Congress, the amount will be carried in a deficiency bill.

The budget carries $150,000,000 for the federal-aid highway system. For grade-crossing eliminations it is proposed that $10,000,000 be appropriated. This $10,000,000 comes out of the $50,000,000 authorized for the fiscal year 1938. In the opinion of the engineers of the Bureau of Roads $10,000,000 will be all that can be expended during the next fiscal year. An additional $5,000,000 is to be appropriated for secondary roads. For roads in National forests $14,000,000 is asked, while an item of $2,500,000 covers the road program in non-taxable Indian lands and roads through unreserved public lands.

Reclamation work

Of the total to be expended for public works in the Interior Department, $10,397,000 is intended for the projects of the Bureau of Reclamation. For those projects, however, it will be necessary to appropriate only $9,665,000, the Director of the Budget estimates. Those estimates are as follows:

Roza Division, Yakima project, $1,500,000; Gila, $1,250,000; Payette Division, Boise project, $1,000,000. Provo project,

(Continued on page 71)

Road Builders Begin Annual Convention

Highway safety is the principal theme of the 34th annual convention of the American Road Builders' Association being held this week at New Orleans. Ten thousand engineers, contractors, and equipment and materials men from all over the United States, Canada, Mexico, and Central America are in attendance.

Willard Chevalier, president of the association, declared in his opening address that it is high time that the road building industry be no longer regarded as merely a field of relief employment and be restored to its normal function of providing efficient transportation facilities at the lowest possible cost to taxpayers. Only when the industry does return to a normal basis, he said, can engineers do the necessary planning to build much needed safety into the highway system.

Thomas H. MacDonald, chief, U. S. Bureau of Public Roads, said that the current year's highway program could reach $800,000,000 if states fully matched federal aid, but he expressed doubt that this total would result because of the excessive diversion of state funds.

The convention program is full of technical sessions covering every phase of highway design, construction, and maintenance. Some 130 talks and papers are scheduled for the four-day meeting. The road show in connection with the convention is limited to exhibitions of materials and accessories, but 129 manufacturers have booth space on two floors of the municipal auditorium with many representatives in attendance.

Public Works Department Asked

President recommends a department of public works and change of Interior Dept. to Dept. of Conservation

The creation of a department of public works was recommended by President Roosevelt in a special message to Congress on Jan. 12. Under this plan the Department of the Interior would become the Department of Conservation. This is the second time that such a recommendation has been made, but it is believed that the prospects for Congressional approval of the proposal are better than when a somewhat similar plan was urged by President Harding because of the large majority which the administration enjoys in Congress.

The President's message was based on a report prepared by a special committee appointed to study the problem. In its report the committee expresses the opinion that there is at present no adequate agency in the structure of the federal government under which public works activities could be centralized. No attempt has been made by the committee or the President to suggest at this time what bureaus and agencies would be assigned to the new department. The committee believes that this is a task that should be handled by the President after "careful research and discussion with those most intimately involved" after the enactment of a law authorizing the suggested changes in the departmental structure.

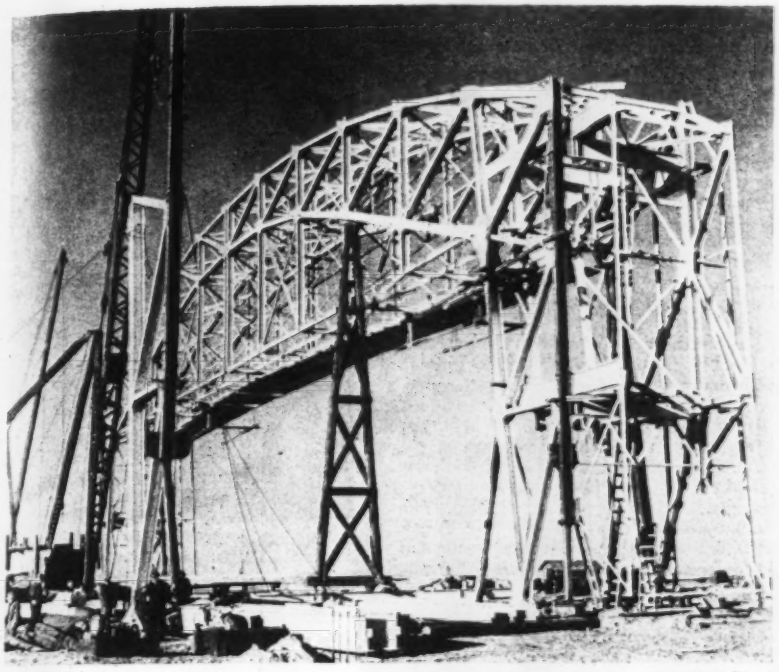
Engineer Corps not affected

Opposition to the plan by supporters of the Corps of Engineers was forestalled by assurances that plenty of work would be provided for the officers of that service. It was pointed out that the army engineers are intended for wartime service and that it is essential to the national defense that they be supplied with work during peacetime as a part of their training.

In his message, President Roosevelt emphasized the need for an organization that would make good management possible. However, he held out no hope for large savings, pointing out that in the states where intelligent reorganization has been effected, the saving has been only about 1 per cent.

Other recommendations for governmental reorganization embodied in the message include the formation of a department of social welfare. In addition to the creation of the two new departments, it is proposed to improve the organization of the President's office by providing six executive assistants as points of immediate contact with the departments. It is proposed that the Comptroller-General be supplanted by an Auditor-General who would be stripped of authority to pre-audit accounts. The Bureau of the Budget would be reorganized, and non-policy-determining higher officials would be put on

(Continued on page 71)



Acme Photo

THE FIRST STEEL rises for the 1939 San Francisco World Fair. This big bent, representing the beginning of the building program for the fair, will be part of one of two airplane hangars, each 335 ft. long by 287 ft. wide. The site of the fair is on a new artificial island in the bay.

New Congress Brings Rush of Bills

Lonergan introduces two bills aimed at stream pollution—new regional Authorities asked

The opening of the 75th Congress brought the usual rush of bills, most of which will never receive any serious consideration but a few of which may soon become important.

Outstanding among the bills introduced into the Senate was S.13, the revised Lonergan bill, which is now before the Senate committee on commerce. The measure follows the general lines of the bill which failed of passage at the last session. It provides for the permanent establishment of the National Resources Committee and directs that it shall be composed of the Secretaries of the Interior, War, Treasury, Agriculture, Commerce, and Labor and the Federal Emergency Relief Administrator. The President might also appoint three additional members. The committee would be charged with co-ordinating activities of the states, encouraging uniform state laws against stream pollution, making studies of pollution problems, and arranging or making loans for sewage disposal plants and treatment of trade wastes. Establishment of sanitary water districts is made mandatory under the bill as is the establishment of district boards charged with prevention of pollution of waters. Injunction proceedings against pollution are provided for under the commerce and navigation powers of the government.

Further continuing his campaign against stream pollution, Senator Lonergan has introduced a bill (S.15) to amend an act of March 1899 dealing with the deposit of refuse in navigable waters and section 3 of the oil pollution act of 1924. The amendment would strike out the words in the 1899 act, "other than that flowing from streets and sewers and passing therefrom in a liquid state," and substitute the words, "including sludge, corrosive substances, and sewage from which the bulk of the suspended and floating matter has not been removed and sewage in a liquid state, as well as other matter."

Senate Bill S.18 would establish a national safety standards commission to reduce the danger of accidents at highway grade crossings and draw-bridges; S.255 would add the Cumberland River basin to the jurisdiction of the TVA; and a joint resolution SJ.Res.19 would authorize the President to appoint a committee to study the financial affairs of all reclamation projects and to recommend adjustment.

Among the hundreds of bills introduced into the House of Representatives, were the following:

HR.159—directing the Bureau of Public Roads to locate and survey three transcontinental highways, six north-south highways, and eighteen airports at their intersections. The roads to be 60 to 80 ft. wide on 200-ft. rights of way, hard-surfaced and lighted, and not to pass through any city, town or village. The airports to be not less than 8,000 ft. square.

HR.146—requiring bidders on public building projects costing over $5,000 to name the sub-contractors and the material and supply men whose services they intend

(*Continued on page* 71)

Nyack Bridge Report Is Unfavorable

Rockland-Westchester Crossing Authority finds bridge would cost more than $9,000,000, tunnel at least $21,500,000

The Rockland-Westchester Hudson River Crossing Authority, created by the 1935 session of the New York legislature and authorized to construct a causeway and tunnel or bridge between Tarrytown and Nyack, N. Y., has filed a majority report with the governor declaring that either the proposed bridge or tunnel would far exceed any cost which could be liquidated by tolls.

The authority found that the suggested site was a good one from the point of view of traffic, and that a crossing costing not more than $9,000,000 could be liquidated by a 50-cent toll. This figure was based on the assumption of a 45 per cent PWA grant.

The authority found the site highly unfavorable, however, from a construction point of view. A 2½-mile crossing would be necessary, and suitable foundations are not available at depths exceeding 200 ft. at the site of the main piers. Also, the War Department will require that the span over the navigable channel have a 1,000-ft. horizontal clearance and a 155-ft. vertical clearance if a bridge is built.

The authority also studied the possibility of building a tunnel under the navigable channel to an artificial island reached by a long causeway across the shallow part of the river. It estimated that the cost would be at least $21,500,000.

The Authority therefore concluded that the construction of either a bridge or a tunnel at the location indicated is impracticable from an economic standpoint.

The Rockland-Westchester Hudson River Crossing Authority, which was appointed by the governor under the 1935 law, is headed by Col. Frederick Stuart Greene, state superintendent of public works. The other two members are Joseph E. Hughes, and Alexander M. Potter. The Authority was provided with an appropriation of $40,000 for exploratory borings, engineering, and other expenses. Mr. Potter, a consulting engineer, is reported to have submitted a minority report favoring the construction of a tunnel.

Cincinnati Housing Contract Awarded to David Gordon

The David Gordon Construction Co. of Cincinnati, Ohio was ordered to start work Jan. 4 on the superstructure for Laurel Homes, PWA's $6,500,000 slum clearance project in Cincinnati. The company was recently awarded the contract for the superstructure on their low bid of $3,690,000.

The foundations for the 19 buildings in the project have been completed by the Torson Construction Co. of Cincinnati, and work on the superstructure is starting immediately.

Laurel Homes will house 925 families in three- and four-story fireproof apartments. Each dwelling unit will be supplied with electric lighting, mechanical refrigeration, gas cooking, and steam heat.

Wage Rates Show Sharp Rise

Common labor rate reaches new high level for average of twenty cities, and the skilled rate approaches 1930 level

Construction wage rates have taken another sharp upturn in January. The *Engineering News-Record* average skilled wage rate for 20 cities has jumped to $1.24 from $1.18 in December, and the common wage rate average climbed to $0.603 from $0.586 in December. This is an all-time high. Common labor in August, 1936, with an average of $0.569, topped the previous high of $0.565 in December, 1929. The common labor average in January exceeds the pre-depression high in 1929 by 7 per cent, while skilled labor in January is only 89 per cent of the way back to its 1930 top.

These averages illustrate the lag in reaction of union rates both in a falling and in a rising market. The steady rise in both skilled and common labor averages in the last eighteen months has been due in large measure to a stiffening in the lower range. In many cities the non-union rate has over-taken the union rate.

New union agreements

The sharp upturn in the skilled average in January is due to a number of new contract periods for union agreements that started Jan. 1.

Other agreements have matured since the first of the year, and in still other localities, either wage rates or hours per work week are under discussion, as follows:

New York highway contractors, in convention at Albany, prepared to go before the state legislature at the present session with a request for legalizing a 10-hr. day, 60-hr. week. This proposal is based on results of survey among labor gangs on road construction who favor an opportunity to earn a larger gross income during the seven-month period they normally are employed.

The Texas Highway Commission increased wages 5c. an hour effective Dec. 1.

In St. Louis, several additional building crafts advanced their wage scales back to the 1929 levels effective on Jan. 4: Structural iron workers went from $1.47 to $1.75 an hour; hoisting engineers from $1.47 to $1.75 for multiple-drum, and from $1.35 to $1.50 for single-drum hoists; sheet metal workers from $1.37½ to $1.50; carpenters from $1.25 to $1.50; building laborers from 78¾c. to 87½c. an hour. The hoisting engineers have been receiving this increase for from one to four months. The Master Builders Association accepted this scale on Sept. 1 and the Municipal Contractors Association on Dec. 1.

Building trade unions in Denver are now taking referendums among members on notification of demands for sharp increases in wages at the expiration of present contracts April 1. Proposed scales include carpenters and cement finishers, who seek an increase from $1.30 to $1.50 an hour, common laborers from 62½c. to 75c. Bricklayers, whose contract expired Jan. 1, have agreed to continue at $1.25 an hour, until April when they are to receive an increase to $1.50.

The Tennessee Valley Authority, on Jan. 5, approved a new wage schedule granting increases of about 10 per cent in hourly rates for some 5,000 workers, with no change in the intermediate or unskilled labor rates. Pay now ranges from 45c. an hour for unskilled labor to $1.10 and $1.25 for most skilled trades.

The United Carpenters and Joiners Brotherhood, convening at Lakeland, Fla., on Dec. 11, voted endorsement to a proposal for a 5-day, 30-hr. work week. Delegates approved a suggestion that the brotherhood's constitution be amended to advocate federal legislation providing for a 30-hr. instead of a 40-hr. work week as previously requested.

The State Highway Commission at Ames, Ia., Dec. 29, approved the proposal of the Des Moines city council to provide union wage scales for labor on the proposed S. W. Twenty-First Street viaduct. The rates for this one project will be: Skilled labor, $1.25 an hour instead of the highway commission minimum of 66c.; intermediate, 80c. an hour instead of 55c.; and unskilled, 67½c. instead of 50c. The Des Moines city council has agreed to pay the difference between the union rate and the highway commission minimum for this viaduct.

Carpenters and painters struck for higher wages in Rochester, N. Y., Jan. 7, following failure of conference between contractors and union representatives on wage scale contracts for 1937. Carpenters are asking $1.25 an hour, last offer by contractors was $1.20. Painters ask $1.37½ and have been offered $1.15. About 400 carpenters and 250 painters are affected by the strike.

TVA Asks for Time Extension On Muscle Shoals Valuation

The Tennessee Valley Authority has asked Congress for an extension of time in which to complete its investigation into the present value of the property at Muscle Shoals turned over to it for management, including the dams, nitrate plants, and power plants, and into the proportion of such value that should be allocated to flood control, navigation, national defense, power development, and fertilizer production. Submission of this report by Jan. 1, 1937 was directed by the TVA Act as amended in 1935.

The request for a time extension has been referred to the Senate Committee on Agriculture and Forestry. No estimate as to the amount of additional time needed was given.

Toll Reduction to Be Made On Bay Bridge

A reduction in tolls on the San Francisco-Oakland Bay Bridge from 65 cents to 50 cents per passenger automobile has been announced for Feb. 1. Reduction has been made possible by agreement of federal authorities to decrease the rate of interest on the R.F.C. loans with which the bridge was constructed. Agitation in California for reduction below the 50-cent figure suggests that costs be met from gas tax funds as are costs on other parts of the highway system.

William Bowie Retires

William Bowie, chief of the division of geodesy of the Coast and Geodetic Survey, retired on Dec. 31, having reached the age limit of 64.

Major Bowie received his education at St. Johns College at Annapolis and Trinity College at Hartford, from which last institution he received the degree of B.S. in 1893; in 1895 he received the degree of C.E. from Lehigh University. In July of that year he entered the service of the Coast and Geodetic Survey as a field engineer, and except for service in the Corps of Engineers during the World War, in which service he rose to the rank of major, he has been connected with the U.S.C.G.S. ever since.

In January, 1909, Major Bowie became assistant chief of the division of geodesy, and in October of the same year he became chief of that division, which post he held until his retirement.

Major Bowie is the chairman of the board of surveys and maps of the federal government. He has written extensively on geodesy and isostasy.

Contractors Withdraw Bids On Bayonne Terminal

J. Rich Steers, Inc. and the Standard Dredging Co. which jointly were awarded the contract for dredging and bulkheading the proposed Bayonne port and industrial terminal, have asked that they be relieved of the $3,548,500 contract, which has not been completed, and asked the return of their surety bonds, amounting to $1,502,000.

The bidders give as the reason for their action the many delays in starting the work and their belief that the legal difficulties in the way of the project cannot be overcome.

An agreement for the construction of the terminal between the city of Bayonne and Central District, Inc., the city's construction agent, was voided last month by the New Jersey Supreme Court on the ground that it gave a monopoly in the terminal to the Central Railroad of New Jersey (*ENR*, Dec. 24, 1936, p. 909).

More Public Works In New Budget

(*Continued from page 68*)

$750,000; Casper Alcova, $750,000; Hart Mountain division, Shoshone project, $700,000; Salt River, $500,000; Pine River, $500,000; Owyhee, $500,000; Sun River, $300,000; Colorado River basin investigations, $250,000; Ogden River project, $250,000; Carlsbad, $200,000; Riverton project, $200,000; Belle Fourche, $130,000; Klamath project, $125,000; Willwood division, Shoshone project, $10,000. In addition $750,000 is asked for administrative expenses.

Appropriations of $15,000,000 are asked for the Central Valley project in California and $7,250,000 for the Grand Coulee dam project. These projects also carry an item of $750,000 for administrative expenses.

While it is estimated that $5,000,000 will be expended on construction work in Boulder Canyon during the next fiscal year, it will be necessary to appropriate only $1,000,000, the budget states. Expenditures for the All-American canal are estimated at $2,500,000, of which only $1,000,000 will have to be appropriated.

Other public works appropriations for the Interior Department include parks, roads and trails, $5,000,000; Blue Ridge parkway, $5,000,000; construction on Indian reservation irrigation systems, $2,090,000; building construction on Indian reservation, $1,905,000; and roads on Indian reservations, $3,000,000.

Appropriation of $3,900,000 is proposed for the Rio Grande project to be expended by the International Boundary Commission. That proposed appropriation is divided as follows: Rio Grande canalization, $1,500,000; Lower Rio Grande flood control project $1,500,000; Rio Grande rectification project, $900,000.

War Department appropriation

While the budget estimates that only $130,000,000 can be expended for general public works of the War Department during the fiscal year, it suggests that appropriations exceed that amount by $13,322,101. The total it is proposed to appropriate for the War Department is made up as follows: Rivers and Harbors, $90,822,101; Omnibus Flood Control Act, $30,000,000; Mississippi River Flood control, $22,500,000.

Tennessee Valley Authority

The actual appropriation for the Tennessee Valley Authority is fixed at $43,000,000, although it is estimated that $54,291,108 will be expended during the fiscal year, in part as follows: Navigation, flood control, and hydro-electric program, $49,460,867; fertilizer and soil conservation program, $3,606,600; national defense program, $312,899; regional studies, $357,242. This latter item includes land planning projects, $150,000; social and economic projects, $80,400; forestry projects, $50,000; research and experimentation, $41,300; geologic investigations, $35,432. The national defense program consists principally of maintenance of the idle nitrate plants.

The public works appropriations for the Department of Commerce go entirely to the Bureau of Lighthouses for the construction of vessels and aids to navigation. One light ship and one tender are to be constructed and other vessels are to be reconditioned.

The general public works for the Department of Justice includes construction at prisons at Leavenworth; Atlanta; Lewisburg, Pa.; Chillicothe; Reno; Springfield, Mo.; Alderson, W. Va.; Petersburg, Va.; La Tuna, Texas; Midland, Mich.

Public buildings

Since there are unexpended balances that can be applied, it will be necessary to appropriate only $40,131,963 for federal public buildings. That total is subdivided as follows: public buildings outside of the District of Columbia $23,000,000; Grand Central Station post office, $10,106,963; War Department buildings, $3,000,000; government printing office annex, $1,500,000; new building for Bureau of Printing and Engraving, $2,325,000; acquisition of existing building in the District of Columbia $2,000,000.

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Department of Public Works Asked by President

(*Continued from page 68*)

a career basis. All existing independent agencies would be assigned to one or the other of the twelve departments.

The commission on whose studies the President based his message was composed of Louis Brownlow, Charles E. Merriam, and Luther Gulick. Mr. Brownlow, a former commissioner of the District of Columbia, has been director of the Public Administration Clearing House since 1931. Mr. Merriam, a member of the National Resources Committee, was formerly professor of political science at the University of Chicago. Mr. Gulick is executive director of the Institute of Public Administration and a member of the Columbia University faculty.

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Paper Company Lets Contract On Big Development Project

A contract let by the St. Joe Paper Co. of Florida to James E. Stewart & Co., of New York City, for construction of a $6,800,000 pine-pulp mill at Port St. Joe, Fla., is the first part of a $20,000,000 development project.

About two-thirds of the cost of the plant is for machinery and equipment. The remainder will be spent on buildings, docks, and waterfront facilities on the harbor of Port St. Joe, about 175 miles east of Pensacola.

An additional contract will be let before Feb. 1 for construction of a model city for workers and officials. Between 500 and 700 houses must be built, besides stores, amusement facilities, streets, waterworks, sewerage, and other necessities. This will represent an outlay of about $10,000,000, in addition to the cost of the paper plant. Railroad facilities, several other factories, and general public dock and harbor facilities will bring the total cost of the Port St. Joe project to $20,000,000.

George F. Hardy of New York City has been appointed designing engineer.

SOCIETY CALENDAR

AMERICAN ENGINEERING COUNCIL, annual assembly, Washington, D. C., Jan. 14-16.

AMERICAN INSTITUTE OF CONSULTING ENGINEERS, annual dinner meeting, New York, N. Y., Jan. 18.

NATIONAL CRUSHED STONE ASSOCIATION, annual convention, Cincinnati, Ohio, Jan. 18-20.

AMERICAN SOCIETY OF CIVIL ENGINEERS, annual meeting, New York City, Jan. 20-23.

ENGINEERING INSTITUTE OF CANADA, annual meeting, Montreal, Canada, Jan. 29-30.

ASSOCIATED GENERAL CONTRACTORS OF AMERICA, annual convention, San Antonio, Texas, Feb. 15-17.

AMERICAN CONCRETE INSTITUTE, annual meeting, New York, N. Y., Feb. 23-25.

AMERICAN RAILWAY ENGINEERING ASSOCIATION, annual meeting, Chicago, Ill., March 16-18.

NEW JERSEY SOCIETY OF PROFESSIONAL ENGINEERS AND LAND SURVEYORS, annual convention, Paterson, N. J., Jan. 16.

COLORADO SOCIETY OF ENGINEERS, annual meeting, Denver, Colo., Jan. 15-16.

LOUISIANA ENGINEERING SOCIETY, annual meeting, New Orleans, La., Jan. 22-23.

NEW YORK STATE SEWAGE WORKS ASSOCIATION, annual meeting, New York City, Jan. 21-23.

WYOMING SOCIETY OF ENGINEERS, annual meeting, Cheyenne, Wyo., Jan. 22-23.

AMERICAN WOOD PRESERVERS ASSOCIATION, annual meeting, New Orleans, La., Jan. 26-28.

NATIONAL PAVING BRICK ASSOCIATION, annual meeting, Detroit, Mich., Jan. 27-29.

CONNECTICUT SOCIETY OF CIVIL ENGINEERS, annual meeting, New Haven, Conn., Feb. 16-17.

SOUTHWEST ROAD SHOW AND SCHOOL, Wichita, Kansas, Feb. 23-26.

ASSOCIATION OF HIGHWAY OFFICIALS OF NORTH ATLANTIC STATES, annual convention, New York, N. Y., Feb. 24-26.

MINNESOTA FEDERATION OF ARCHITECTURAL AND ENGINEERING SOCIETIES, annual convention, St. Paul, Minn., Feb. 26-27.

NEW JERSEY SEWAGE WORKS ASSOCIATED, annual meeting, Trenton, N. J., March 11-12.

LICENSE EXAMINATIONS

NEW YORK Examinations for professional engineering originally scheduled for Jan. 25-27 have been postponed to Feb. 1-3, and the examination for land surveying originally scheduled for Jan. 28 has been postponed to Feb. 4.

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New Congress Brings Rush of Bills

(*Continued from page 69*)

to use in fulfilling the contract involved.

HR.18—declaring it to be the policy of the United States that no public money shall be expended directly or indirectly for irrigation or reclamation purposes.

HR.108—permitting the Secretary of the Interior to defer water right charges falling due in 1935 on irrigation projects on which payment would be unduly burdensome.

HJR.11—changing the name of Pickwick Landing Dam to Rankin Dam.

HR.92—placing the operation of Bonneville Dam, when completed, under the corps of engineers, with rate regulation by the Federal Power Commission (this is the same bill that failed passage in the last session).

HR.117—establishing a Columbia Valley

Authority modeled after the TVA and turning over to it the works at Bonneville and Grande Coulee.

HR.182—establishing a Missouri Valley Authority along TVA lines.

HR.275—establishing a Wisconsin Valley Authority.

HR.161—reducing the interest rate on HOLC loans to 3 per cent.

HR.153—appropriating $9,700,000 for the construction of Caddoa Reservoir in Colorado and Kansas.

HR.114—authorizing a study of the Cabinet Gorge power and reclamation project on the Clark Fork of the Columbia River near the Montana-Idaho boundary.

HR.40—permitting state and local taxation of federal lands used for a housing project in Buffalo, N. Y.

HR.173—authorizing a federal appropriation of not more than $30,000,000 for improvements to the New York State Barge Canal, provided the state furnishes $10,000,000.

HR.1489—creating a U. S. Housing Authority as an independent agency to promote low-cost housing through financial assistance to local government.

HR.1544—creating a U. S. Housing Authority under the direction of the Secretary of the Interior.

HR.1599—authorizing the Secretary of the Interior to make 80 per cent grants for low-cost housing.

HR.287—to provide that money paid contractors on public works shall constitute a trust fund to be applied first to the payment of claims.

HR.1505—directing the completion of the Florida ship canal.

New capital for the week amo... of $7,004,000: state and municipal $5,104,000, and corporate issues, $1...

LARGER AWARDS FOR THE W...EEK

Kraft pulp and paper mill, St. Joe Paper Co., Port St. Joe, Fla.....	$...
Power house annex, Iowa Public Service Co., Waterloo, Ia.....	...
Refinery, Dixie Refining Co., Trenton, Mich.	...
Hot mill, Reeves Manufacturing Co., New Philadelphia, O.....	...
Carbon Black plant, Witco Carbon Co., Sunray, Tex.....	...
Field house and gymnasium, Purdue University, West Lafayette, Ind.	...
Wendell-Phillips High School, Chicago, Ill.	...
Highways, Arkansas.....	...
Highways, Indiana.....	...
Signal system, San Francisco—Oakland Bay Bridge.....	...
Bridges, Connecticut.....	...
Southwest Sewage Treatment Works, Div. 2, Chicago, Ill.....	...
Southwest Intercepting Sewer, contract No. 6, Chicago, Ill.....	...
Dam No. 3, Mississippi River, Red Wing, Minn.	...
Spillway gate operating machinery, Ft. Peck Dam, Ft. Peck, Mont...	...

CONSTRUCTION STATISTICS FOR THE WEEK

ENGINEERING construction awards for the week total $43,889,000. This total is made up of private, $19,584,000; public $24,305,000; federal, $2,863,000; and state and municipal, $21,442,000. Corresponding values a week ago were: Total $40,447,000; private, $21,244,000; public $19,203,000; federal, $3,704,000 and state and municipal, $15,499,000. The volume for the same week last year was: total, $102,534,000; private, $7,177,000; public, $95,357,000; federal, $40,631,000; state and municipal, $54,726,000.

Increases this week over last are registered in sewerage, bridges, commercial buildings, earthworks and drainage, streets and roads, and unclassified. The classified subtotals are: waterworks, $901,000; sewerage, $4,249,000; bridges, $4,478,000; industrial buildings, $13,052,000; commercial buildings, $5,152,000; public buildings, $6,508,000; earthwork and drainage, $2,903,000; streets and roads, $4,102,000; and unclassified, $2,544,000.

INDEX NUMBER

ENR Cost	1913 =100	1926 =100	ENR Volume	1913 =100	1926 =100
Jan., 1937	223.45	107.41	Dec., 1936	206	99
Dec., 1936	220.67	106.07	Nov., 1936	176	85
Jan., 1936	199.48	95.89	Dec., 1935	254	122
1936 (Av.)	206.46	99.24	1936 (Av.)	185	89
1935 (Av.)	195.22	93.84	1935 (Av.)	137	66
1934 (Av.)	198.10	95.23	1934 (Av.)	111	53

CONTRACTS
(Thousands of Dollars)

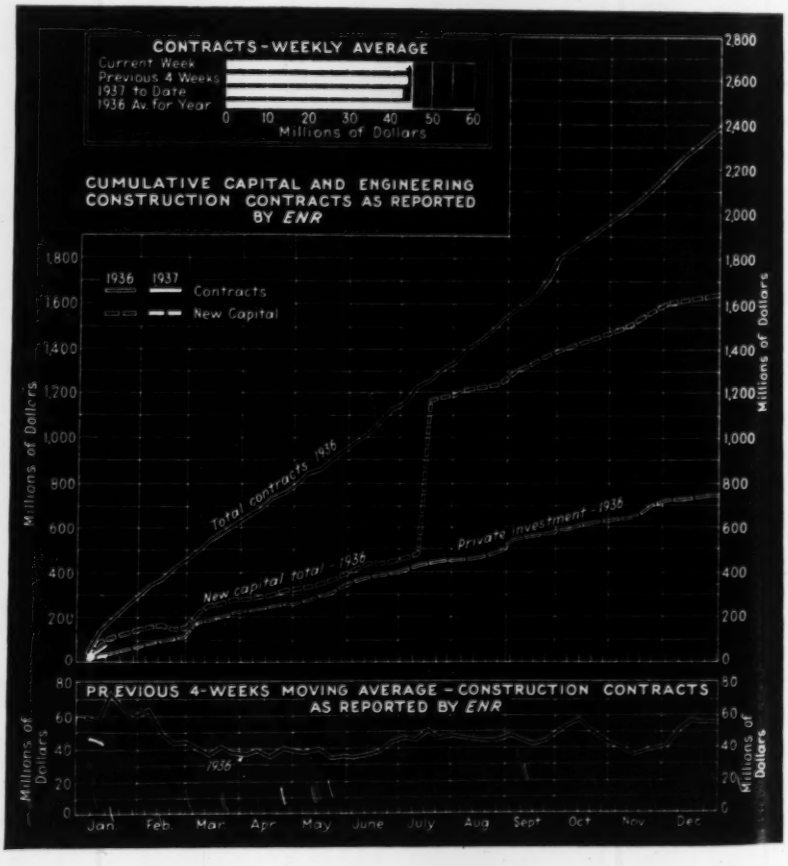
	Weekly Average Jan. 1936	Prev. 4 Weeks	Week Jan. 14 1937
Fed. Government	$10,437	$2,164	$2,863
State and Municipal	38,655	17,414	21,442
Total public	$49,092	$19,578	$24,305
Total private	8,617	23,716	19,584
Week's total	**$57,709**	**$43,294**	**$43,889**
Cumulative to date: 1936	$69,635,000	1937	$84,336,000

Note: *Engineering News-Record* reports waterworks and earthwork, reclamation or waterways projects of $15,000 and over in size; other public works, $25,000; industrial buildings, $40,000; other buildings, $150,000 and over. The figures above represent the volume of contracts and large force account projects throughout the U. S. that are of these minimum sizes or over.

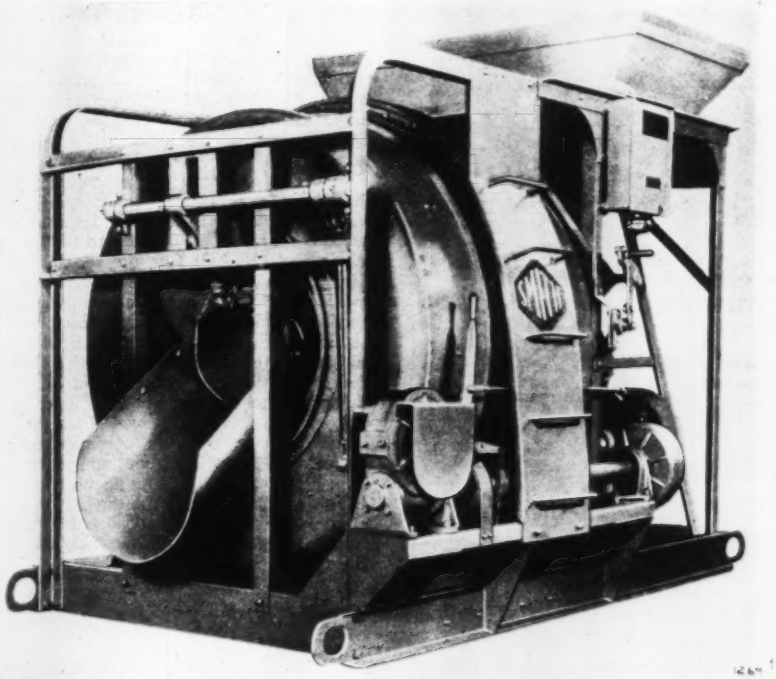
NEW PRODUCTIVE CAPITAL
(Thousands of Dollars)

1937	Week Jan. 14	Cumulative
Private investment	**$7,004**	**$13,318**
State and municipal bonds	5,104	11,178
Corporate securities	1,900	2,140
Federal financing	.....	**875**
PWA non-federal projects	.....	875
Total non-federal	**$7,004**	**$14,193**
Federal projects	.....	.....
Total	**$7,004**	**$14,193**
Cumulative to date: 1936	$88,621,000	1937	$14,193,000

Note: These figures include private bonds and stocks sold for new construction purposes; state and municipal bonds for construction; PWA loans and grants to states and municipalities. RFC direct purchase of bonds for "self liquidating" projects, and 25 per cent of WPA construction appropriations.



Construction Equipment and Materials



New 28-S Mixer

The T. L. Smith Co., of Milwaukee, have developed a new 28-S non-tilt mixer, said to incorporate marked improvements in speed and efficiency. A new variable speed drive is intended to make the machine equally efficient on either dry or wet batches, and the drum is narrow with an extra large diameter for faster charging and discharging.

The drum is equipped with renewable full width liners and full width converging buckets. The wearing edges of these buckets are coated with a new hard alloy metal developed by the Smith Co. This surface coating is said to increase the life of the bucket.

The design of the machine incorporates an end-to-center mixing action. The machine has an enclosed gear reduction unit, and the power discharge is direct-connected to the countershaft with the worm and gear running in oil. A multiple V-belt drive is used.

Versatile New Crane

The mobile wagon crane developed by the Browning Crane & Shovel Company, of Cleveland, Ohio is said to combine the advantages of the truck-mounted and the crawler crane. With a speed and mobility approximating that of the truck crane, it can be operated by one man and possesses the short turning radius of the crawler crane.

The crane is mounted on tires, either pneumatic or solid, and has a self-propelled travel speed of 2 to 6 miles per hour. The propelling mechanism can be quickly disengaged, and means are provided for towing the crane at high speed behind an ordinary truck. The crane has a maximum lifting capacity, with outriggers, of 15,000 lb. on the 20-ft. boom and of 11,800 lb. on the 40-ft. boom.

The crane can be converted, with no change back of the boom feet except for the drum lagging, to handle a hook block, a clamshell bucket, a dragline bucket, a shovel dipper, a back hoe, or a set of pile driver leads.

Bristol Adds Line of Electric Meters

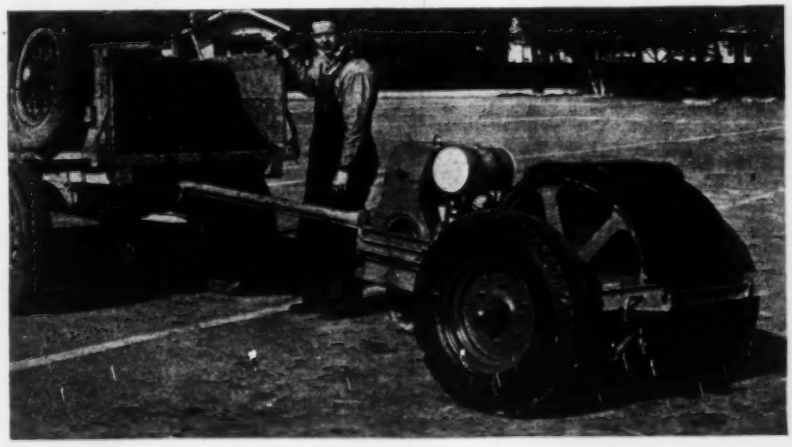
The Bristol Company (Waterbury, Conn.) has added a complete line of electric flow meters for steam, liquids and gases to its line of mechanical flow meters. These meters operate on the same principles as the mechanical meters which the company has been manufacturing in the past. The readings are transmitted over a simple two-wire circuit, telephone circuits included, which does not enter into the calibration of the instrument. All electrical contacts are enclosed in glass. A standard Bristol meter body is employed to measure the differential across the orifice. Conduit openings are provided so that the instrument may be used with modern wiring systems.

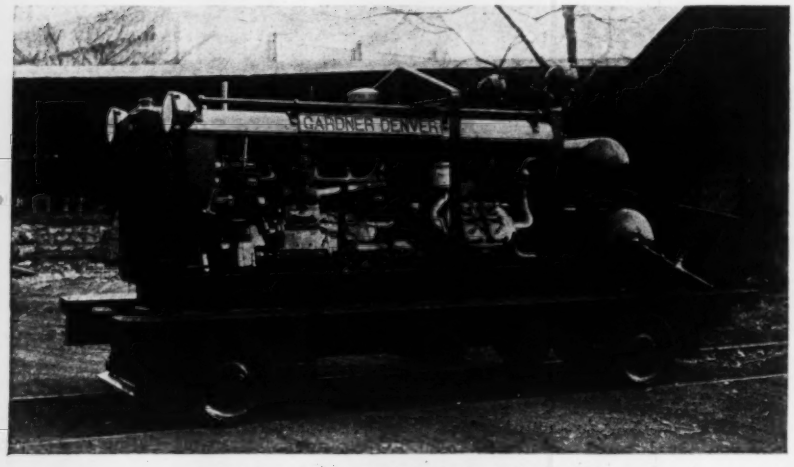
Small Power Roller

The Wheeled Roller No. 135, manufactured by the Wheeled Roller Corp., San Antonio, Texas has a compaction of 135-lb. per in. and is said to sell for less than any other power roller having the same compaction.

The roller is towed to the job behind a truck, running as a trailer on pneumatic tires. On the job, the operator lifts the tongue up and over, converting the device into a roller. He then guides the roller, driven by an air cooled gasoline engine back and forth over the area to be rolled. The roller has a travel speed forward and reverse of from 1 to 2½ mi. per hour under its own power.

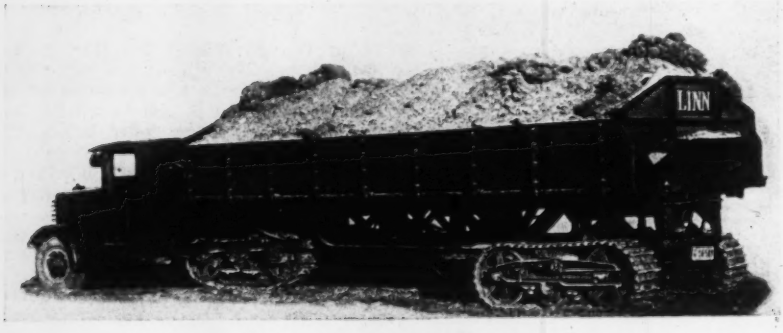
The roller drum is 24 in. in width and 32 in. in diameter and weighs about 2,350 lb. The engine is mounted on an independent frame, and remains in an upright position regardless of whether the device is running as roller or trailer.





SELF-PROPELLED COMPRESSOR

THIS new railroad-type compressor, manufactured by the Gardner-Denver Company of Quincy, Ill., is Caterpillar diesel powered and self-propelled by an air motor. It is equipped with tractor type headlights front and rear. The machine is manufactured in the Gardner-Denver Company's full line of sizes. The model illustrated is the WBF 210.



30-YD. TRACTOR-TRAILER

THIS is the new Model 37-P combination tractor-trailer developed by the Linn Manufacturing Corporation, of Morris, N. Y., with a body capacity of 25-30 cu. yd. This device employs the standard Linn tractor chassis with an especially designed trailer unit. The trailer body is two-way dumping, with heavy-duty underbody hoist and automatic down-fold side gates. The dumping angle is 50 deg. The trailer is powered with a six-cylinder Hercules gasoline engine or, optionally, with a diesel motor.

High Speed Incorporated In New Drifter

The new 150-lb. drifter, the model DA 35, is said by the Ingersoll-Rand Co. (New York City), the manufacturers, to be the fastest drill they have ever built. They recommend it for any heavy drifting job. The extra drilling speed and low air consumption are said to have been achieved by means of a new double-opening, direct-flow valve of small diameter, light weight, and short travel.

The standard Ingersoll-Rand auto-feed can be applied to this new drifter, making it feed automatically in any position of the drill.

The company recommends the use of jackbits and jackrods to get the full advantage of the potentialities of this new drilling equipment.

Mine Car Loader

A new mine car loader developed by the Gardner-Denver Company, of Quincy, Ill., is intended to permit more rapid loading in mining and tunnelling operations to match the efficiency of modern drilling equipment.

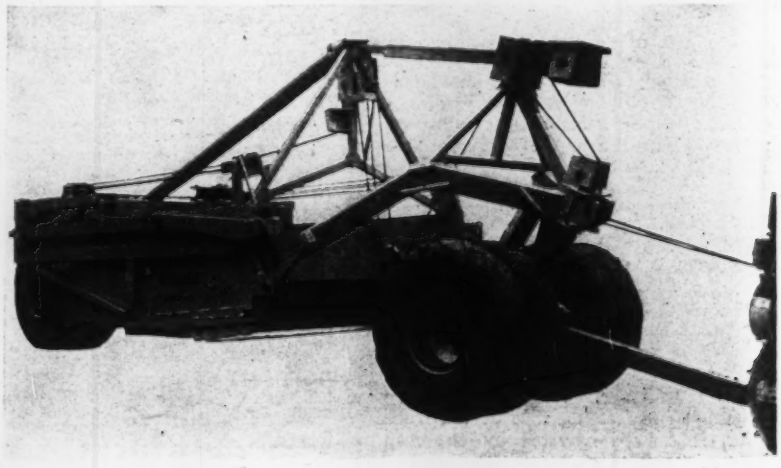
The loader is powered by two compressed air motors, one for crowding or propulsion and the other for the loading dipper. The motors are of the 5-cylinder radial type operating on air pressures of 45 to 90 lb. Their consumption is said to be about that of a medium size drill. The motors and the gear reductions are lubricated by the splash system.

In operation the loader is crowded into the broken rock by one of its compressed air motors with the dipper lowered and a standard mine car coupled to the loader. When the dipper is full, the second motor lifts it backward over the loader and the rock is discharged into the car. The body may be swung to either side to handle rock outside of the track on which it runs, and an automatic centralizing device brings the dipper into proper position for discharging into the car. As the dipper empties, the loader is moved backward a short distance, and the operation is repeated. The loading time when the car is in position is said to be about 1 min.

The wheel tires and the digging lips are of molychrone steel, heat treated. Various track gages are accommodated by changing the wheels only.

Expanding Scraper

A telescoping construction of the bowl is incorporated in the new Type U expanding carryall developed by R. G. LeTourneau, Inc., of Peoria, Ill. The bowl consists of two buckets, the rearmost of which telescopes within the forward bucket. When the carryall is loading, this rear bucket fills and is then carried back by a return spring, thus expanding the bowl capacity and increasing the yardage 50 per cent. As a result of this construction the 18, 12, 9, and 6-yd. sizes of the Type U carryall have the same cutting width as the 12, 8 and 6-yd. carryalls, respectively, in the older design. Thus, it is said, the Type U carryall loads extra yardage with very little extra tractor effort necessary.



BUSINESS SIDE OF CONSTRUCTION

1936 Registers 50 Per Cent Gain *ENR* Cost Index Continues to Rise

MAJOR engineering construction closed 1936 with a 50 per cent gain over 1935 and with several new records in individual classes of work. The totals for 1936 as reported by *Engineering News-Record* are $2,386,845,000 of which private is $766,007,000, a 106 per cent gain over 1935; public, $1,620,838,000, a 33 per cent gain. Of the public, federal works accounted for $319,538,000 and state and municipal for $1,301,300,000, a 52 per cent gain and an all time high for this classification. *Engineering News-Record* reports waterworks and irrigation, earthwork and waterways projects of $14,000 and over in size, other public work of $23,000 and over, industrial buildings of $37,000 and over and other buildings of $140,000 and over. On January 1, 1937, these minimum screens will advance to $15,000, $25,000, $40,000 and $150,000 respectively due to a corresponding increase in the construction cost index average for 1936.

The 1936 totals are for a 53 week year due to the fact that 53 Thursdays fall in it. December accordingly was a five week month and recorded a total major construction of $266,301,000, the highest weekly average for any month since January. This high volume was due to the highest rate of private awards since August 1930, a total of $140,999,000 for the month. Public awards totalled $125,302,000 of which $23,845,000 was federal. Corresponding values for the 4 weeks of November are: total, $162,743,000; private, $59,462,000; public, $103,281,000; federal, $20,177,000. For December, 1935, 4 weeks, these values are: total, $235,506,000; private, $28,413,000; public, $207,093,000; federal, $58,941,000.

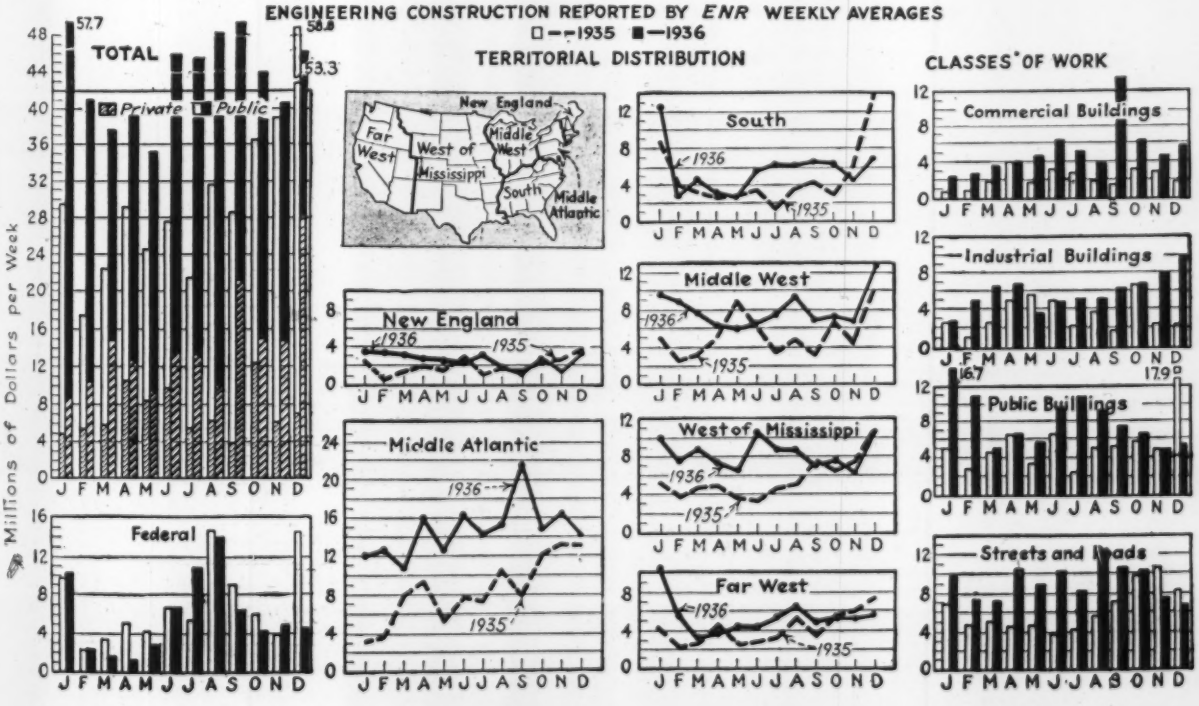
Thus the closing months of 1936 recorded a spectacular rise in private construction. For the year as a whole private construction showed the highest gain of any department of the field, 106 per cent, but major public works as defined above chalked up the highest year in history. This record was made in the state and municipal classification, since federal construction volume dropped back 12 per cent from the 1935 mark.

ENGINEERING CONSTRUCTION CONTRACTS REPORTED BY *ENGINEERING NEWS-RECORD* IN DECEMBER, 1936

Engineering News-Record *reports projects of the following minimum costs: Water-works, excavation, drainage and irrigation,* $14,000; *other public works,* $23,000; *industrial buildings,* $37,000; *other buildings,* $140,000.

Five Weeks — Thousands of Dollars (000 Omitted)

	New England	Middle Atlantic	South	Middle West	West of Mississippi	Far West	United States December 1936	United States Twelve Months 1936	United States Twelve Months 1935	Canada
Public Works										
Waterworks	378	631	162	699	3,011	2,219	**7,100**	**92,478**	80,677	72
Sewerage	327	3,156	139	2,740	858	692	**7,912**	**121,056**	99,935	250
Bridges, public	2,453	4,218	1,523	4,057	3,206	931	**16,478**	**173,749**	86,861	59
Earthwork and waterways	274	601	4,029	903	9,185	1,764	**16,756**	**181,685**	258,740	601
Streets and roads	1,105	8,375	9,807	3,351	7,009	2,922	**32,569**	**483,475**	325,263	1,500
Buildings, public	153	5,742	1,521	11,181	3,522	3,736	**25,865**	**435,926**	297,858	107
Unclassified, public	2,635	9,399	406	687	3,378	2,117	**18,622**	**132,469**	69,678	204
Total public	**7,325**	**32,122**	**17,597**	**23,618**	**30,259**	**14,381**	**125,302**	**1,620,838**	**1,219,012**	**2,793**
Federal government (included in above classifications)	84	1,896	5,039	4,470	9,394	2,962	**23,845**	**319,538**	362,265	.....
Private										
Bridges, private	.....	2,252	78	.....	23	.....	**2,353**	**14,067**	11,072	.....
Buildings, industrial	4,611	5,586	12,927	23,888	1,143	1,475	**49,630**	**309,477**	172,467	888
Buildings, commercial	4,850	17,260	390	3,210	839	1,740	**28,289**	**274,784**	108,817	140
Unclassified, private	122	13,464	4,230	13,113	20,886	8,912	**60,727**	**167,679**	78,783	.....
Total private	**9,583**	**38,562**	**17,625**	**40,211**	**22,891**	**12,127**	**140,999**	**766,007**	**371,139**	**1,028**
Total Engineering Construction:										
December, 1936 (5 weeks)	**16,908**	**70,684**	**35,222**	**63,829**	**53,150**	**26,508**	**266,301**	.....	.....	**3,821**
November, 1936 (4 weeks)	5,451	65,369	18,222	27,247	24,970	21,454	162,743	.....	.....	10,793
December, 1935 (4 weeks)	15,386	51,124	55,416	40,425	43,573	29,582	235,506	.....	.....	422
Twelve months, 1936	**148,295**	**775,769**	**308,725**	**423,135**	**444,978**	**285,933**	.....	**2,386,845**	.....	**93,783**
Twelve months, 1935	101,631	441,940	245,303	280,494	295,136	225,647	.....	.....	1,590,151	81,008



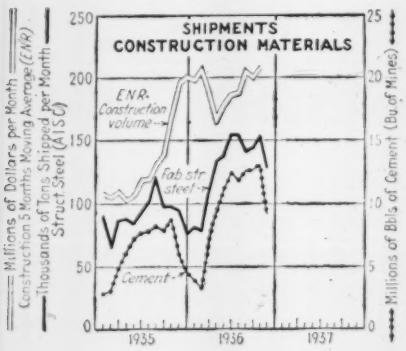
The types of construction conspicuous for their large volume in 1936 are bridges and grade crossing elimination, $187,816,000; sewers and sewage treatment, $121,056,000 and public buildings, $435,926,000, all all-time records. Industrial buildings at $309,477,000, climbed to a volume level exceeded only in 1929.

Geographically, the Middle Atlantic states regained their strong leadership in construction volume and gains of varying amounts are recorded in all territories.

New Capital

New capital for construction purposes totalled $55,742,000 in December, $26,231,000 from state and municipal bond sales, $17,524,000 from corporate security sales and $11,987,000 from PWA allotments.

The year's record shows a strong shift from federal to private investment financing. State and municipal construction bond sales to private investors totalled $698,529,000 for the year compared with $497,-



102,000 in 1935 and corporate security sales for construction total $251,516,000 in 1936 compared with $38,296,000 in 1935. These are increases of 41 and 557 per cent respectively.

Materials

Portland Cement—The Portland cement industry in Novemer, 1936, produced 10,968,000 barrels, shipped 8,962,000 barrels from the mills, and had in stock at the end of the month 20,086,000 barrels. Production and shipments of Portland cement in November, 1936, showed increases, respectively, of 54.6 and 50.0 per cent, as compared with November, 1935. Portland cement stocks at mills were 7.1 per cent lower than a year ago according to reports by the Bureau of Mines.

The ratio of production to capacity for November was 50.9 compared with 56.0 in October and 32.2 in November a year ago.

Cement prices were dropped in December on the eastern seaboard. The new prics were reported in *Engineering News-Record*, January 7.

Steel—The average operating rate of steel companies having 98 per cent of steel capacity of the industry who report to American Iron and Steel Institute was 77.5 for December compared to 74.6 a month ago and 51.6 a year ago.

New business booked by the structural steel fabricating industry during November declined less than it did last year, according to reports received by the American Institute of Steel Construction. New business booked this month totalled 50.3 per cent of normal (normal being the average yearly rate during 1928-1931). New business booked during the 11 months of the year averaged 55.5 per cent of normal. Shipments in November declined from the high rate of previous months, but were larger in total volume than new orders booked.

The estimated total tonnage for the entire industry was 128,306 for November compared with 94,746 a year ago and 1,413,352 for the 11 months compared with 1,019,002 a year ago.

Lumber—In December, the lumber industry averaged 54 per cent of 1929 production and 55 per cent of 1929 shipments according to reports of the National Lumber Manufacturers Association.

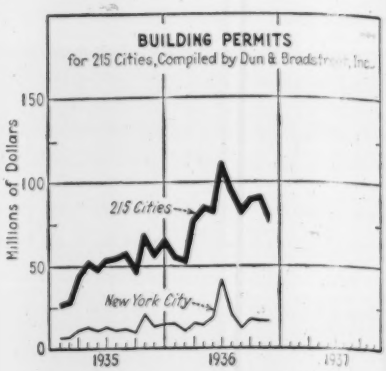
Lumber prices in a number of centers have reflected an uncertainty due to the maritime strike.

Building Permits

Although above the corresponding period of the preceding year for the twenty-third month in succession, the volume of building permits for November displayed a seasonal decline from October. The estimated cost of work covered by permits issued in 215 cities last month, according to the latest report compiled by Dun and Bradstreet, Inc., amounted to $75,464,623, against $56,276,588 in November a year ago, or an increase of 34.1 per cent.

Labor

Decreases of 2.1 per cent in employment and 0.2 per cent in weekly pay rolls were shown between October and November by reports received from 9,545 private building contractors employing 117,500 workers in November 1936. The November 1936 declines are less pronounced than those reported between October and November in the 5 preceding years for which figures are available. The previous declines in employment in November ranged from 2.3 per cent to 9.5 per cent and the pay roll decreases ranged from 3.0 per cent to 11.3 per cent. Employment in the private building construction industry in November 1936 was 32.7 per cent above the level of the corresponding month of 1935 and pay rolls show an increase of 61.2 per cent over the interval. The reports cover em-



ployees engaged in erecting, altering, and repairing private buildings and do not include employees engaged on projects financed by the Public Works Administration, Reconstruction Finance Corporation funds, or regular appropriations of the Federal, State and local governments.

More than 3,133,000 workers were employed on projects of the works program in November, an increase of 57,000 over the number employed in October. The increase occurred on that part of the program operated by the Works Progress Administration and was partially accounted for by an expansion of employment in the drought areas. Over 2,726,000 of the workers engaged on the works program were employed on projects operated by the Works Progress Administration.

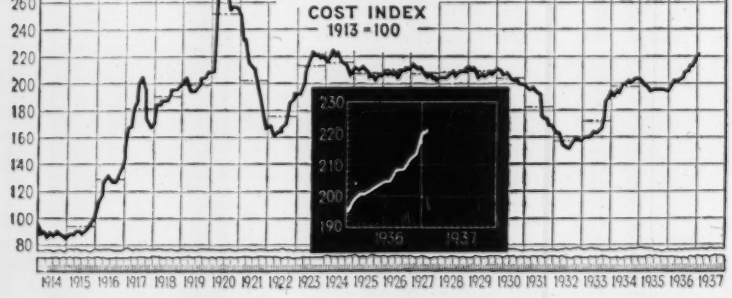
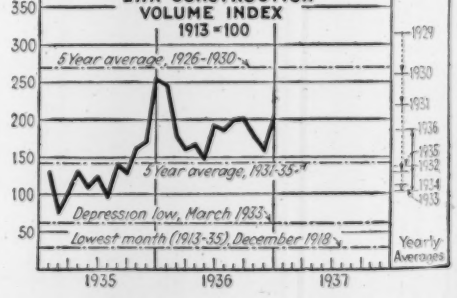
On construction projects financed from funds provided by the Public Works Administration 270,000 were employed in November. Compared with October this was a decrease of 27,000 or 9 per cent in the number of wage earners.

Wage rates which have been climbing steadily took another sharp upturn in January. The labor situation is reported in more detail in the news pages of this issue, both as to trends and as to local negotiations completed or under way for 1937 contracts affecting either hours or rates or both.

ENR Cost and Volume Index

THE *Engineering News-Record* Construction Cost Index rises to 223.45 in January, the highest value since March, 1921. This rise is due to record high rates for common labor.

The *ENR* Volume Index for December is 206.

INDEX NUMBER

ENR Cost	1913 = 100	1926 = 100	ENR Volume	1913 = 100	1926 = 100
Jan., 1937	223.45	107.41	Dec., 1936	206	90
Dec., 1936	220.67	106.07	Nov., 1936	159	70
Jan., 1936	199.48	95.89	Dec., 1935	254	111
1936 (Av.)	206.46	99.24	1936 (Av.)	185	81
1935 (Av.)	195.22	93.84	1935 (Av.)	135	58
1934 (Av.)	198.10	95.23	1934 (Av.)	114	50